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Human Factors Analysis of Road Weather Advisory and Control Information: Final Report

Battelle
Meridian Environmental Technology, Inc.
Texas Transportation Institute

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16. Abstract

The amount of available weather information and the methods by which this information can be disseminated to travelers have grown considerably in recent years. This growth includes weather gathering devices (sensors, satellites), models and forecasting tools for predicting weather conditions, and electronic devices used by drivers (Internet, in-vehicle devices, roadway signage). This project was initiated in order to best-align available weather information content and presentation to travelers' information needs and wants, as well as being communicated in ways that travelers will use. The specific objectives of this project were to:

1. Identify the weather information requirements of travelers across a representative number of travel scenarios.
2. Evaluate the current state of the practice in weather-responsive traffic advisory and control strategies in terms of meeting those information requirements.
3. Recommend ways to improve those practices including the development of communication and messaging standards.

A set of improvements and guidelines have been recommended to support Transportation officials in communicating both pre-trip and en route road weather information effectively, consistently and timely to meet the needs of drivers and travelers for different weather conditions and travel scenarios.

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Acronyms and Abbreviations

APA... American Psychological Association
AASHTO ....American Association of State Highway and Transportation Officials
ATIS...Advanced Traveler Information System
ATWIS.. Advanced Transportation Weather Information System
CMS .... Changeable Message Sign
CV .... Commercial Vehicle
CVO ....Commercial Vehicle Operations
DMS...Dynamic Message Sign
DOT ....Department of Transportation
FHWA...Federal Highway Administration
GPS ....Global Positioning System
HAR .... Highway Advisory Radio
IRB.. Institutional Review Board
ITS...Intelligent Transportation System
MoE..Measure of Effectiveness
MUTCD .... Manual on Uniform Traffic Control Devices
NWS... National Weather Service
PDA..Personal Digital Assistant
PED ....Personal Electronic Device
PV .... Passenger Vehicle
RSS ....Really Simple Syndication
RWIS..Road Weather Information System
SME .... Subject Matter Expert
TCD...Traffic Control Device
TD ....Travel Decision
TMC...Traffic Management Center
TRB...Transportation Research Board
VMS.. Variable Message Sign
WSDOT .... Washington State Department of Transportation

EXECUTIVE SUMMARY

Background and Objectives

The last decade has seen tremendous growth in both the amount of available weather information, as well as the methods by which this information can be disseminated to travelers. This growth includes weather gathering devices (sensors, satellites), models and forecasting tools for predicting weather conditions, and electronic devices used by drivers (e.g., Internet, in-vehicle devices, roadway signage; National Research Council, 2004); however, unless the content, format, and timing of available weather information is consistent with what travelers need, want, and will use, then such information may not be useful and—in certain situations—may even lead to reduced mobility, as well as unsafe driving decisions and behaviors.

To address this important need, Federal Highway Administration (FHWA) sponsored an effort to help transportation professionals provide road weather messages that better accommodate the information needs and information usage patterns of the general traveling public. The *Human Factors Analysis of Road Weather Advisory and Control Information* project was intended to:

- Identify the weather information requirements of travelers across a representative number of travel scenarios.
- Evaluate the current state of the practice in weather-responsive traffic advisory and control strategies in terms of meeting those information requirements.
- Recommend ways to improve those practices including the development of communication and messaging standards.

Summary of Project Methods

At the outset of this research effort, very little information was known about the human factors issues that directly impact how travelers seek out and use road weather information, and what decisions that this information should support. We conducted several activities to bring together available information from other related domains, such as traveler information systems and commuter decision making, in addition to supplementing this information with analytical activities, such as developing traveler scenarios and collecting brief questionnaire data to obtain to obtain limited information about key knowledge gaps.

Another important element in communicating road weather information to travelers is the method used to provide this information. There is a variety of different dissemination methods (DMs) available, such as television, commercial radio, personal electronic devices PEDs, road weather website, Highway Advisory Radio (HAR), and Dynamic Message Signs (DMS), among others. Other key questions are how is communicating of road weather information constrained by the technological capabilities of these dissemination methods, and what is there availability at different points during a traveler's trip (e.g., prior to leaving, en-route, etc.)?

Several activities were conducted to provide the supporting information necessary to develop message design recommendations. The activities primarily included a variety of analytical activities, such as travel scenario development and literature searches; however, these were supplemented by questionnaire data collected from 92 travelers at freeway rest areas in the Seattle area. The design recommendations themselves took the form of structured design guidelines. In addition, a separate "design tool" was developed to provide a systematic procedure to facilitate incorporating human factors considerations and specific traveler information needs into message design. These activities are summarized below in Figure ES-1.

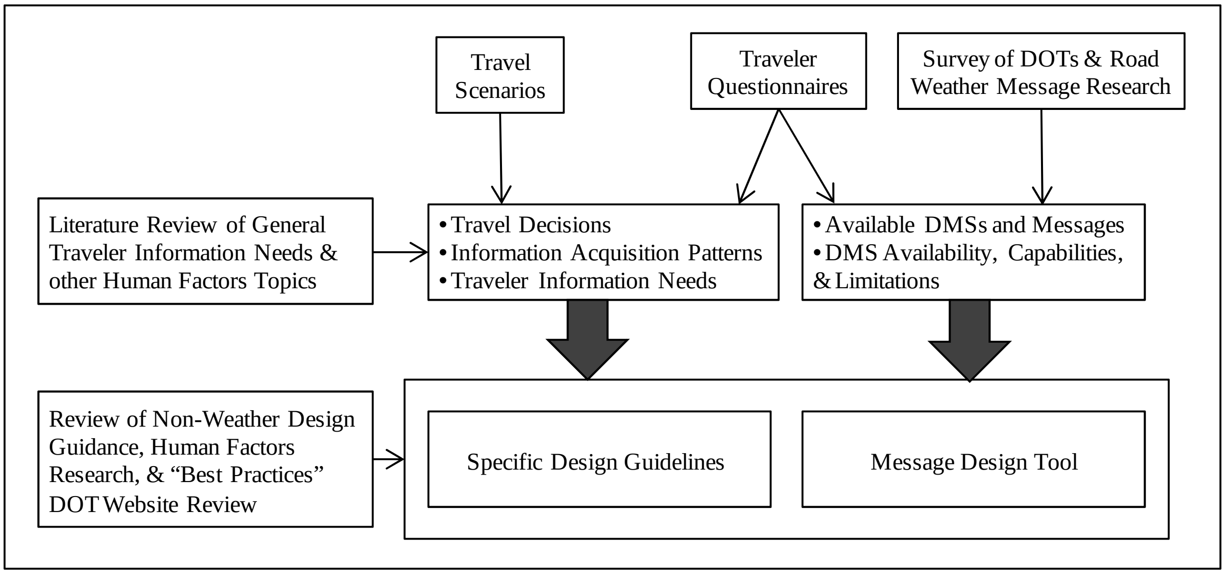

Figure ES-1. Flow diagram showing how the activities conducted in this research effort supported the development of the road weather message design guidelines.

The work from this effort resulted in a set of recommended improvements and guidelines for road weather information communication that meets the needs of the drivers and travelers for different weather conditions and travel scenarios. These recommendations have the potential to facilitate and support:

- Effective and timely dissemination of road weather information by individual transportation agencies and others.
- Weather messages that are more: useful, understandable, accurate, and specific.
- Informed pre-trip decisions by travelers regarding routes, modes, and departure times.
- En route decisions by travelers that are more likely to reflect actual conditions and lead to safer driving behaviors.
- A more consistent approach to the content and delivery of road weather information across cities, states, and regions.

Summary of Results

The primary output of this effort was an initial set of road weather message design guidelines. In addition to these, supporting materials were also developed, including a message design tool for incorporating traveler information needs into message design (referred to as the "message design tool"), and tutorials covering certain human factors issues related to communicating road weather information to travelers. A list of the guidelines developed in the current research effort is presented in Table ES-1. It is important to note that, although the term "guidelines" is used to refer to road weather design information, this is done more as a convenience to simplify discussion of this design information, and not to suggest that these are formal guidelines that are ready for implementation. As discussed in the Conclusions section, this guideline development activity was conducted with minimal input from the target end-user community that will be responsible for using this information to develop road weather messages, and additional work is required to better support the information needs of this group.

A total of 30 guidelines were developed covering content and wording of messages, message presentation and layout, and other general issues, such as communicating information about urgency or uncertainty. An example guideline is shown in Figure ES-2, and the key format and layout elements are also described. In most cases, different design recommendations were provided for different types of dissemination methods. More specifically, the guidelines focused on three different types of dissemination methods, including:

- **Short text/visual messages:** Brief text-only messages that have space/character-number restrictions (e.g., DMS, cellular text-messaging, Twitter, etc).
- **Open format text/visual messages:** Visual message formats that are not inherently restricted in terms of length and can include graphical elements, such as maps, icons, or video (e.g., web-pages and information kiosks).
- **Auditory messages:** Spoken word messages involving pre-recorded or synthesized voice messages, with no visual elements (e.g., 511 or HAR).

Although specific design recommendations may not be identical for all dissemination methods from the same type, they are similar enough that the basic design principles should still apply across methods. Clear exceptions were noted in the discussion section of applicable guidelines.

Note that some topics do not have a guideline for certain types of dissemination methods. This is typically because the guideline information is not relevant to a dissemination method type, such as the use of fonts or color in auditory messages. These cases are indicated as cells that are shaded gray in Table ES-1.

Table ES-1. Design guidelines look-up table.

Guideline Topics	Applicable Dissemination Method Types		
	DMS, Text Message, PED	*Website, Kiosk*	*HAR, 511*
	Short Text/Visual	Open-format Text/Visual	Auditory
General Message Content & Wording			
Message Content	G-01	*	G-02, G-03
Message Length	G-04		G-05
Message Structure			G-06
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Use of Table Information		G-24	
Communicating Timeframe	G-25	G-25	G-26
Communicating Geographic Extent	G-27	G-19, G-20	G-28
Communicating Degree of Urgency	G-29	G-29	G-29
Communicating Degree of Certainty	G-30	G-30	G-30

*Blank, shaded cells indicate that a guideline topic is not applicable or there is insufficient information to provide one.

**Guidelines indicated in blue bold apply only to non-DMS short message dissemination methods.

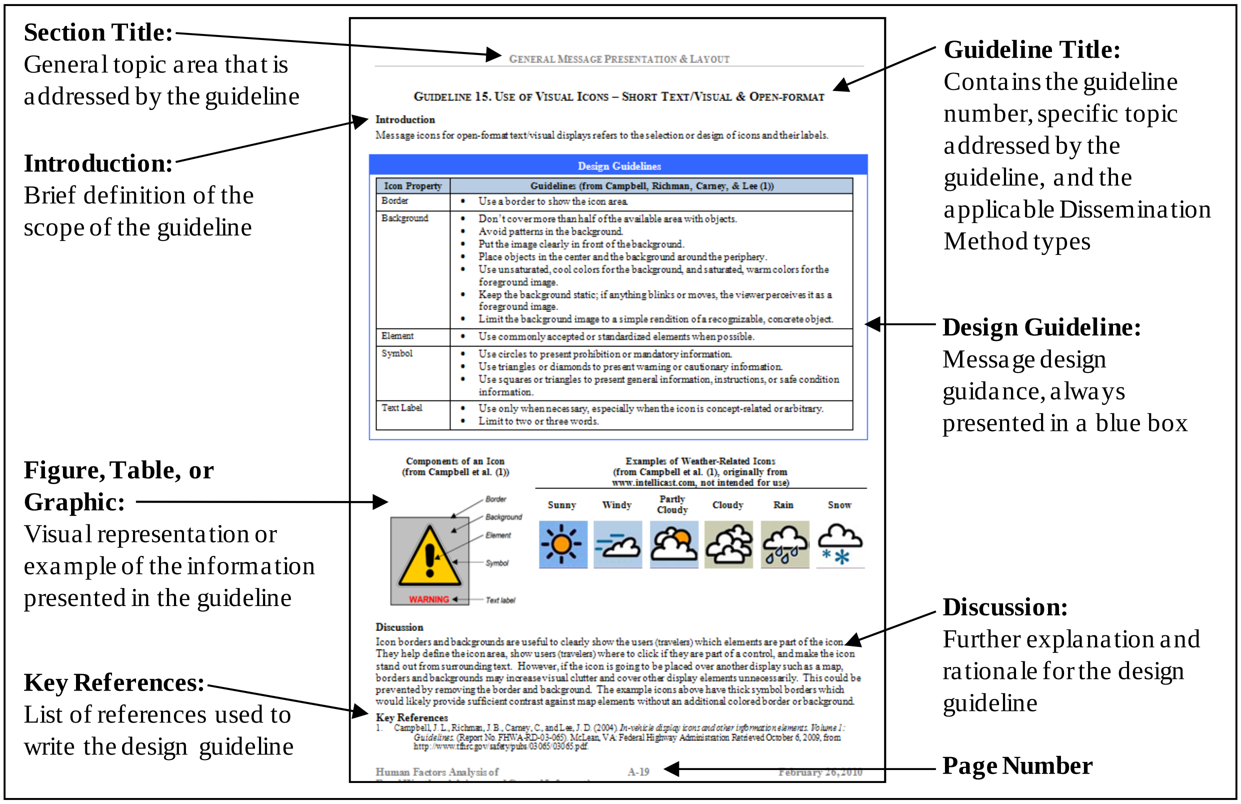


Figure ES-2 Basic layout of the design guidelines with descriptions of the key format elements.

Conclusions and Recommendations

Three primary conclusions have emerged from this effort:

1. The project has resulted in an initial set of guidelines and recommendations for road weather information communication and presentation. The guidelines and recommendations have the potential to improve the content and delivery of road weather information.

2. The guidelines and recommendations reflect best practices, as well as the best-available information from the research literature. Most data sources are not weather-specific.

3. End-users have had no involvement in developing the content, format, and organization of the guidelines and recommendations. The guidelines should be further-tailored to end-users' needs and requirements.

In addition, the project team has developed a set of recommendations for improving and disseminating these guidelines in the future. First, the preliminary guidelines presented in this report should be rigorously evaluated by a representative group of end-users drawn from state

DOT staff, TMC staff, and perhaps other agencies. The guidelines should then be revised to reflect the recommendations and insights provided by these end-users. Specifically, as-needed, refinements and improvements should be made to the organization, format, and content of the guidelines. Second, a set of outreach activities intended to attract, engage, and involve the end-user community should be implemented. These outreach activities should include a mix of workshops, conference/journal articles, presentations at state/regional DOT meetings, web-based forums (i.e., webinars), e-mail guidelines and updates, and the provision of links to the guidelines/project on relevant websites.

The rationale for this approach is straightforward: a message design tool is the most efficient way to integrate the large number of different possible combinations of weather events, safety and mobility impacts, traveler decisions and behaviors, and dissemination methods into specific recommendations for road weather messages. In particular, the "problem space" associated with these various combinations is so large that providing specific guidance for each combination would result in a product that would be unwieldy and—ultimately—of little use to state DOT staff and other end-users of the message design guidelines.

CHAPTER 1: INTRODUCTION

Overview

The last decade has seen tremendous growth in both the amount of available weather information, as well as the methods by which this information can be disseminated to travelers. This growth includes weather gathering devices (sensors, satellites), models and forecasting tools for predicting weather conditions, and electronic devices used by drivers (e.g., Internet, in-vehicle devices, roadway signage; National Research Council, 2004). However, unless the content, format, and timing of available weather information is consistent with what travelers need, want, and will use, then such information may not be useful and—in certain situations—may even lead to reduced mobility, as well as unsafe driving decisions and behaviors.

To address this important need, the *Human Factors Analysis of Road Weather Advisory and Control Information* project was initiated in order to:

1. Identify the weather information requirements of travelers across a representative number of travel scenarios.
2. Evaluate the current state of the practice in weather-responsive traffic advisory and control strategies in terms of meeting those information requirements.
3. Recommend ways to improve those practices including the development of communication and messaging standards.

Meeting these objectives will result in a set of recommended improvements and guidelines for road weather information communication and presentation that meets the needs of the drivers and travelers for different weather conditions and travel scenarios.

The recommendations for improving the presentation and timing of road weather advisory and control information for travelers that this project has yielded have the potential to facilitate and support:

- Effective and timely dissemination of road weather information by individual transportation agencies and others.
- Weather messages that are more: useful, understandable, accurate, and specific.
- Informed pre-trip decisions by travelers regarding routes, modes, and departure times.
- En route decisions by travelers that are more likely to reflect actual conditions and lead to safer driving behaviors.
- A more consistent approach to the content and delivery of road weather information across cities, states, and regions.

Project Approach

The project consisted of the following activities:

- Identify traveler weather information requirements and review current practices in road weather information dissemination.
- Review and propose methodology for assessing the usefulness, quality and effectiveness of weather-related messages and dissemination methods in terms of the traveler information requirements.
- Develop research plan and conduct human factors study on road weather information.
- Identify improvements to existing messages and methods and recommend relevant standards for communicating weather information to travelers.

We also conducted a series of project management activities, primarily in support of facilitating accurate and continuous communications between the team and the Federal Highway Administration (FHWA), including a project kick-off meeting, development of a project plan, and regular reporting activities.

This report represents the final report from this project and consists of the following chapters and appendices:

- Chapter 2 summarizes the objectives, methods, and results associated with identifying traveler requirements for road weather information.
- Chapter 3 summarizes the objectives, methods, and results associated with conducting a review of existing road weather advisory and control information.
- Chapter 4 summarizes the objectives, methods, and results associated with conducting an evaluation of existing road weather advisory and control information.
- Chapter 5 summarizes the objectives, methods, and results associated with developing preliminary guidelines for disseminating road weather information.
- Chapter 6 summarizes implementation and evaluation strategies.
- Chapter 7 provides a discussion of the conclusions that the project team has developed from the project, as well as our recommendations for how to implement, test, and communicate the results of this research effort.
- Appendix A summarizes the information collected from state DOT contacts and websites.
- Appendix B lists the data sources we reviewed and summarizes our findings.
- Appendix C provides a copy of the Road Weather Information questionnaire.
- Appendix D summarizes the literature reviewed in light of the key project questions.
- Appendix E summarizes the traveler decision tool and includes the tutorials.
- Appendix F summarizes the weather website survey results.

CHAPTER 2: TRAVELER REQUIREMENTS FOR ROAD WEATHER INFORMATION

The objective of the activities described in this chapter was to develop an initial set of travel scenarios that could be used in later activities to identify traveler information needs and other aspects related to traveler use of and access to road weather information.

Traveler information requirements are highly situation-specific because drivers differ in many ways that influence their decision making (e.g., time pressures, available routing options, confidence about finding an alternative route, etc.). A useful method for ensuring that these different factors are adequately considered when identifying information needs is to use a scenario-based approach. Scenarios involve detailed “virtual trips,” for which several key trip parameters (e.g., trip purpose, duration, origin, etc) are defined. They help define a broad range of situational parameters that lend themselves to a variety of different travel decisions that should be supported by our efforts to identify traveler information requirements. Importantly, they also act as “reality checks” to ensure that relevant and realistic travel situations are covered in our analyses. This section describes how we developed travel scenarios for identifying information requirements.

Methods

We began by creating an initial set of base scenarios that represented diverse travel situations, such as a work commute trip, recreational travel, or long-haul commercial vehicle operation (CVO). For each of these scenarios, we also wanted to consider a range of weather impacts and dissemination methods that were likely to be relevant with regard to travel decisions that travelers might make in these situations. Accordingly, this methods section also provides definitions for these additional travel parameters, including the likely dissemination methods used in each scenario, when travelers would be likely to access road-weather information, and the definitions of weather impacts that travelers would be facing.

The activities listed below summarize how driving scenarios were developed in this project and the following sections describe each step in further detail.

- **Define scenarios:** This step specified the various trip parameters that distinguish trips based on different characteristics (e.g., different trip purposes, origination points, durations, etc) that influence when, how, and why travelers would use road weather information.
- **Specify likely dissemination methods in each scenario:** This step defined the dissemination methods that road users would have available and be reasonably likely to access based on scenario parameters.
- **Specify likely access points:** This step defined the points during their travel (e.g., en route, before leaving) at which road users could reasonably be expected to access information using the dissemination methods specified above based on the scenario parameters.

- **Define weather impacts:** This step specified the weather impacts (e.g., icy roads) that represented the information about road weather events that transportation officials would need to communicate to travelers.

Define Scenarios

The scenario definitions required selection of scenarios and specifying the associated trip parameters. Each of these activities is described below.

Selection of Driving Scenarios

Driver information requirements are highly situation-specific because drivers differ in many ways that influence their decision making (e.g., time pressures, available routing options, confidence about finding an alternative route, etc.). A useful method for ensuring that these different factors are adequately considered when identifying information needs is to use a scenario-based approach. This can involve developing “narrative” examples of trips in which drivers use road-weather information to make travel decisions involving numerous permutations of possible scenario factors (e.g., such as those described in the Clarus Con-Ops document; Cambridge Systematics, 2003). We used a structure that was less narrative in nature but still retained descriptive elements that allowed us to maintain a plausible and coherent travel scenario. Several different trip parameters were considered when defining individual scenarios. These included: Trip Purpose, Time Constraints, Network Familiarity, Trip Distance, Trip Origin, Regional Differences, Vehicle Type, and Travel Environment. The trip parameters shown in Table 1 were selected to reflect characteristics that capture meaningful ways in which trips can differ, and based on input from the FHWA.

Rationale for the Baseline Scenarios

One limitation of a scenario-based approach, however, is that there are a very large number of possible permutations involving these situational factors, which makes comprehensive consideration of broad range of factors unfeasible. Table 2 shows the full set of scenario travel parameters available for constructing scenarios. Altogether, there were 2592 different possible combinations without taking into account the additional combinations of information access, dissemination method, and weather impacts possible for each of the 2592 permutations. Since creating a table that shows all possible combinations (with the selected scenario parameters highlighted) would be too cumbersome to work with, we only show the travel parameter for the selected scenarios. We developed five (5) baseline scenarios, each of which was combined with multiple dissemination methods, information access, and weather impact parameters to create many more derivative scenarios that allow us to consider information requirements under different travel situations (i.e., Table 1 below).

Table 1. Scenario travel parameters (number of levels in parentheses), levels, and descriptions.

Scenario Travel Parameters	Levels	Descriptions and Comments
Trip Purpose (4*)*	Commuting, Long Distance Travel, Recreational, Work	This is a descriptive variable, but is associated with time constraints, trip origin, and network familiarity.
Time Constraints (3)	High, Medium, Low	Represents the degree to which travel time is important to traveler.
Network Familiarity (3)	High, Medium, Low	Represents the degree of driver familiarity with the road network, which is related to propensity to accept an alternative route. Heavy trucks are inherently constrained to certain routes.
Trip Distance (3)	Less than Half a Day, Half to Full Day, Multi-day	Time it takes to complete the scenario travel.
Trip Origin (2)	Home, Trip-leg	Travel starting location for the day. This is relevant for identifying dissemination methods that drivers can access.
Regional Differences (2)	Single state, Multi-state	Whether the trip is confined to a single state or crosses multiple states.
Vehicle Type (2)	Passenger Vehicle (PV), Commercial Vehicle (CV)	Type of vehicle driven during travel.
Travel Environment (3)	Urban, Rural, Mountain, Interstate	Travel environment that is most relevant for travel decisions involving weather information.

In order to specify the actual base scenarios, we first developed simple descriptions for five different types of trips. Table 2 below provides the basic information for each trip type used to define the scenarios. The description and specific details were used to set specific trip parameter values for each scenario.

Table 2. Basic descriptions of each travel scenario.

Trip Type	Description	Details
Commute	Driver is traveling from home to work and back again later in the day.	• Driver needs to be at work at a specified time. • Regular trip duration is less than 1 hour. • Driver is willing to use alternative transportation modes. • Driver is very familiar with the road network and has a low threshold for traffic delays.
Long Distance Travel	Driver is making a day-long trip in one direction.	• Trip is assumed to require less than a full day of travel, however the driver would like to complete the trip in one day. • Trip covers more than one state. • Driver is moderately familiar with the available routes, and while he/she prefers to remain on the primary/intended route, the threshold for switching to alternate routing is not high.
Recreational Travel	This is more casual driving in which there is a specific destination, but not a strict schedule for arriving there.	• Driver is unfamiliar with the region, and less willing to deviate from the planned route. • Trip starts and ends at a hotel. • Driver has flexibility regarding when to travel, and can delay travel to a different part of the day, or even to a different day (i.e., cancel the trip).
Long-Haul Commercial Vehicle Operation	Trip involves one leg of a multi-day trip that takes the trucker across multiple states.	• Trip leg starts in one state and ends in a different state. • Trip origin is a rest area or truck stop with limited facilities and information access. • Driver is confined to a limited set of interstate roadways with alternative routes that can only easily be accessed at a few junctures. • Driver is very familiar with primary and alternate routes.
Urban Commercial Vehicle Operation	Trip involves a travel as part of local CVO operations confined to a single urban area for one workday	• Trip leg starts at a shipping center/warehouse that is equipped with the information access capabilities needed to provide up-to-date road weather information for the entire day. • Driver is very familiar with primary and alternate routes. • Driver places a high priority on efficient travel with minimal delays.

Finally, the specific travel parameters defined for each basic scenario are shown in Table 3. The overall objective for developing this table was to generate travel parameter combinations that represented a realistic and broad range of situations in which travelers would use road weather information to make travel decisions.

Table 3. Travel parameter definitions for the five selected scenarios.

Trip Parameters							
Trip Purpose	*Time Constraints*	*Network Familiarity*	*Trip Duration*	*Trip Origin*	*Regional Differences*	*Vehicle Type*	*Travel Environment*
Commute	High	High	< ½ day	Home	Same-State	PV	Urban
1-way trip	Med	Med	1 Day	Home	Multi-State	PV	Interstate
Recreation	Low	Low	Multi-day	Trip-Leg (Hotel)	Same-State	PV	Mountain/ Rural
Commercial Vehicle travel	High	High	Multi-day	Trip-Leg (Rest Area)	Multi-State	CV	Interstate
Local CV operation	High	High	1 Day	Home (Warehouse/ Depot)	Same-State	CV	Urban

Identify Likely Dissemination Methods and Access Points in each Scenario

The scenarios listed in Table 4 form the base set of scenarios used in our analysis. For each of these scenarios, we identified dissemination methods and information access points that might reasonably be expected to be associated with each scenario, based on the trip parameters specified. The different options considered for each of these parameters are shown in Table 4 below.

Table 4. Descriptions of information access, dissemination method and weather impact parameters.

Parameter	Options	Descriptions and Comments
Information Access	Trip Planning – Previous Day	Information obtained in advance of departure and used during trip planning.
	Trip Planning – Before Leaving	Information obtained shortly before departure.
	En route-stopped	Information obtained during the trip but not in a moving vehicle (e.g., at a rest stop or restaurant).
	On-road	Information obtained while in a moving vehicle.
Dissemination Method	Local AM/FM Radio	Available on road or stopped.
	TV	Available en route-stopped but not while on road moving.
	Highway Advisory Radio (HAR)	Potential distraction issues if accessed while driving.
	511	Potential distraction issues if accessed while driving.
	Portable Electronic Device (PED)	Represents any portable device (e.g., Personal Digital Assistants (PDAs) and cell phones) that drivers can use to actively seek out web-based information (includes wireless or web-connected global positioning system (GPS) navigation systems). Potential distraction issues if accessed while driving.
	Cellular Phone Messaging	Represents information "pushed" to travelers, such as text-message alerts and RSS feeds. Potential distraction issues if accessed while driving.
	Dynamic Message Sign (DMS)	Available on-road only.
	Information Kiosks	Interactive information kiosks available at stop-over locations, such as some rest areas.

Two of the information access points involved pre-trip planning (Previous Day and Before Leaving). These two options were differentiated because they represent different time constraints. In particular, the "Before Leaving" option was selected to represent situations in which drivers have to depart shortly and are better served by "on-demand" dissemination methods, such as the web or 511, rather than mediums such as local television broadcasts, in which viewers have no control over precisely when they can get weather information. Consequently, travelers would have access to a greater variety of useful dissemination methods options on the Previous Day compared to right Before Leaving. Also, another difference is that drivers can get real-time weather and road condition information Before Leaving, which has more direct implications on travel planning than the forecasts available the Day Before.

Each of the base travel scenarios listed in Table 3 was assigned a relevant set of both information access and dissemination method options. The objective was to be reasonably comprehensive with each set of options.

Define Weather Impacts

Originally, each scenario was associated with a range of road weather events (e.g., fog, blizzard, heavy rain) that travelers would have to consider in their decision making. There were, however, two significant problems with this approach. The first was that this led to a very large number of weather events to incorporate into the scenarios. Second, and more important, this initial set of weather events had many events that overlapped in terms of their implications for the road user. For example, weather events associated with icy roads, freezing rain, heavy snow, blizzards, and heavy rain could all lead to low-traction conditions on the road. This non-orthogonality was addressed by identifying specific *weather impacts* for weather events that represent the functional consequences to road users associated with the prevailing weather events. In the example above, all of those weather events would be associated with the "Reduced Traction" weather impact.

Most of the specific weather impacts are based on those used to develop Traffic Management strategies for addressing various weather events as defined in the FHWA ConOps report on "Weather-Responsive Traffic Management: Concept of Operations" (Cambridge Systematics, 2003). However, some weather impacts were added to cover additional traveler concerns that were not included in the original document (e.g., stranding conditions), and others were changed based on feedback from the FHWA. The full list of weather impacts used in scenario development is provided in Table 5.

Table 5. Definition and associated weather events for each weather impact.

Safety/Mobility Impact	Associated Conditions	Impact on Travelers
Total Road Closure	Blizzard conditions, White-out conditions, Moderate to heavy snow, Sleet or freezing rain, Flooding, Thunderstorms, High winds	Requires detour onto alternate routes or delaying travel.
Reduced traction	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain	Drivers should be more cautious in the affected area.
Low visibility	Blizzard conditions, White-out conditions, Blowing snow, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Smoke/mist/fog	Drivers should be more cautious in the affected area.
Lane Obstruction/ Reduced capacity	Blizzard conditions, White-out conditions, Blowing snow, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Drizzle or light rain, Flooding, Thunderstorms, High winds, Smoke/mist/fog	Likely to cause moderate to high levels of traffic congestion in the immediate area. Debris on roadway, lanes unavailable because of snow obstruction/clearing or partial flooding. Also, vehicles pulling over to side of the road, washed out roadways, or pavement damage.
Congestion/ Reduced speed	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Flooding, Smoke/mist/fog	Greater speed variability in traffic and loss of roadway capacity.
Traffic Control Device (TCD) Malfunction	Blizzard conditions, White-out conditions, Moderate to heavy snow, Sleet or freezing rain, Thunderstorms, High winds	Traffic signals are non-operational leading to increased congestion.
Unsteady Driving/ High Winds	High winds	Drivers (particularly those of larger vehicles/trucks, RVs) should be more cautious in the affected areas.
Flooding/ Water Ponding	Moderate to heavy rain, Flooding, Thunderstorms	Drivers are at risk of being stuck or stranded mid-travel. Potential road closures. Drivers should be more cautious in the immediate area.
Maintenance Vehicles on Road	Blizzard conditions, Blowing snow, Bridge or road frost, Extreme cold, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Flooding, Extreme heat	Drivers should be more cautious in the affected area. Maintenance vehicles on the road may reduce roadway capacity, leading to increased congestion.
Transit, Bus Delays/ Stoppage	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Extreme cold, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Flooding, Thunderstorms, High winds, Smoke/mist/fog	Travel by transit has a higher time cost.
Sun Glare	Extreme heat, Fair weather	Drivers should be more cautious in the affected area.
Extreme Temperatures	Extreme cold, Extreme heat	Drivers should prepare for conditions by bringing along appropriate gear/supplies.

Results

Table 6 shows the scenarios combined with the relevant dissemination methods, information access points, and weather impacts. The information access and dissemination information was assigned to reflect which of these options are available and realistically likely to be used in a particular scenario. The weather impacts are not comprehensively assigned, however they are logically assigned to cover as many unique situations as possible. In particular, most weather impacts can be applied multiple scenarios (e.g., "Loss of power" applies to all urban scenarios and "Reduced traction" applies to all scenarios). In these cases, we tried to minimize redundancy by limiting assignment of weather impacts to weather impact and scenario combinations that resulted in unique impacts on driver decision-making, behavior, etc. For example, Road closures would probably be associated with different travel decisions for recreational travelers (trip cancelation or delay) and long-haul CVO drivers (route change).

We can use Table 6 to obtain basic information about driver information needs. In particular, for each scenario, we can identify three high-level information requirements, including:

1. What weather impacts would travelers need to make travel decisions about? For example:
    a. Fair/mild conditions
    b. Reduced capacity
    c. Transit disruption
    d. Stranding conditions
    e. Loss of power
    f. Reduced visibility
    g. Reduced traction
    h. Reduced speed
    i. "Wall of rain"
    j. Lane obstructions
    k. Extreme temperatures
    l. Stranding conditions
    m. Reduced speed
    n. Road closures
2. When would travelers in the scenarios likely be able to access road weather information? For example:
    a. Previous day(s)
        - Home, hotel, depot or rest area
    b. Just before leaving on a trip
        - Home, hotel, depot or rest area

c. En route
    - Moving and stopped

3. What dissemination methods would they be most likely to use at each of these information access points? For example:
    a. Previous Day (Web, TV, PED, 511)
    b. Before Leaving (Web, PED, 511)
    c. On-road (DMS, 511, HAR, PED, Radio, Cell)
    d. En route-stopped (TV, Kiosk, PED, 511, Web)

Information about the travel decisions underlying weather impacts provides information about the required content of road weather messages, since communication needs to provide the information necessary for traveler to make appropriate decisions based on their situation. Also, information about likely information access points and dissemination methods have implications for road-weather presentation format, such as modality, photometric qualities, auditory qualities, and timing because these aspects govern how effective travelers will be at extracting the information elements they need from weather messages. For example, if some road weather information is best presented on-road using a DMS, it must be presented in a way that can be easily comprehended by a driver moving at high speeds, with possibly limited visibility and limited time available to take their eyes off the road.

Table 6. Travel scenarios and associated trip parameters, information access details, and assigned weather events/impacts.

Travel Parameters (Scenarios)								Info Access (Dissemination Methods)	Weather Events - Weather Impacts
Trip Purpose	*Time Constraints*	*Network Famil.*	*Trip Dist.*	*Trip Origin*	*Reg. Diffs.*	*Vehicle Type*	*Travel Environ.*		
Commute	High	High	< ½ day	Home	Same-State	PV*	Urban	• Previous Day (Web, TV, PED, 511) • Before Leaving (Web, PED, 511) • On-road (DMS, 511, PED, Radio, Cell)	• Fair Weather - Fair/mild conditions • Fog - Reduced capacity • Heavy Rain - Transit disruption • Heavy Snow - Stranding conditions • High Winds - Loss of power
1-way trip	Med	Med	1 Day	Home	Multi-State	PV	Interstate	• Previous Day (Web, TV, PED, 511) • Before Leaving (Web, PED, 511) • On-road (DMS, 511, HAR, PED, Radio, Cell) • En route-stopped (TV, Kiosk, PED, 511, Web)	• Fog - Reduced visibility • Light Snow - Reduced traction • Heavy Rain - Reduced speed • Thunderstorms - "Wall of rain" • Flooding - Lane obstructions • Extreme Heat - Extreme temperatures • Blizzard - Stranding conditions
Recreation	Low	Low	Multi-day	Trip-Leg (Hotel)	Same-State	PV	Mountain/ Rural	• Previous Day (Web, TV, 511, PED) • Before Leaving (511) • En route-stopped (TV, Kiosk, PED, 511, Web) • On-road (DMS, 511, HAR, PED, Radio, Cell)	• Flooding - Stranding conditions • Light Snow - Reduced speed • Blizzard - Road closures • Extreme Cold - Extreme temperatures
Long-haul CVO	High	High	Multi-day	Trip-Leg (Rest Area)	Multi-State	CV	Interstate	• Previous Day (Web, TV, PED, 511) • En route-stopped (TV, Kiosk, PED, 511, Web) • On-road (DMS, 511, HAR, PED, Radio, Cell)	• Frost - Reduced traction • Heavy Rain - Reduced speed • Blizzard - Lane obstructions • Heavy Snow - Road closures
Urban CVO	High	High	1 Day	Home (Depot)	Same-State	CV	Urban	• On-road (DMS, 511, HAR, PED, Radio, Cell)	• Light Snow - Reduced capacity • High Winds - Lane obstructions • Flooding - Road closures

* PV = Passenger Vehicle, CV= Commercial Vehicle

CHAPTER 3: REVIEW OF EXISTING ROAD WEATHER ADVISORY AND CONTROL INFORMATION

The objective of this phase of the project was to review existing road weather information. There were two primary uses for this information. The first was to catalog existing weather messages and dissemination methods from available research and state Departments of Transportation (DOTs). This information was intended to serve as a starting point for developing recommendations for road weather messages. In addition, it would provide some information about the use of various dissemination methods and emerging technologies (i.e., Twitter) that could be covered by message design recommendations.

Specifically, we were looking for:

- **Weather Messages**: Existing weather advisory and control messages used by transportation agencies and other providers of weather information that would include messages on precipitation, visibility, wind and extreme weather events such as thunderstorms, hurricanes, tornadoes, floods, etc., and
- **Dissemination Strategies**: Messages that are posted on the road as well as messages that are disseminated through traveler information systems such as kiosks, websites, in-vehicle navigation systems, DMSs, HAR, cellular phones, 511, and other road weather information portals.

The primary sources of information were available research literature or other related reports that we had on hand, in addition to information from state DOTs. A number of state DOTs were contacted to identify specific weather messages currently being used. The personnel from the DOTs that replied to our information requests are listed in Appendix A. We also systematically catalogued the road weather information features available on individual state DOT websites.

The second use of existing road weather information was to identify methodological approaches that have been used to investigate travelers' use of weather information, and what type of information each can provide. This information was needed to identify candidate research approaches for a data collection activities conducted in later project phases (see Chapter 4).

Methods

The following sections describe our approach for identifying existing road weather messages and information dissemination methods. The primary approaches used included:

- Relevant Documents that the Battelle Team has on Hand
- Literature and Internet Searches on Weather Information and Dissemination Strategies
- Contact Relevant state DOT Personnel
- Searching DOT Websites

Once this information had been gathered, the relevant information about weather messages and dissemination strategies was incorporated into a Microsoft Access™ database, and the corresponding findings were summarized in separate report tables.

Following these sections, another section describes the process for identifying candidate research approaches for the data collection activity described in Chapter 4.

Relevant Documents that the Battelle Team has on Hand

Useful starting points for this activity were the effort conducted under the Aurora Pooled Fund Study (Boselly, 2000), various studies examining traveler information needs (e.g., Lappin, 2000a and 2000b), publications provided by the FHWA's Road Weather management group (e.g., http://ops.fhwa.dot.gov/Weather/resources/publications.htm), and more general human factors publications such as Campbell, Carney, and Kantowitz (1998), Campbell, Richman, Carney, and Lee, (2004), and Dudek (2004).

Also included were numerous reports/publications that the Battelle Team had in house, such as:

- Reports authored by members of the Battelle team,
- Numerous reports, books, articles from the human factors literature providing general guidance on how to present real-time graphical and text information to users,
- DOT-sponsored reports on what drivers need and want with respect to traveler information (mostly surveys and focus groups),
- Numerous documents from recent FHWA-sponsored projects (many performed by the Battelle team) describing the current state of weather integration in Traffic Management Centers (TMCs), and
- Meridian's information archives compiled from their work on the 511 program.

These sources were assembled into a master document list that was subsequently augmented by research articles identified in the activities described below.

Literature and Internet Searches on Weather Information and Dissemination Strategies

Separate literature searches were conducted for both the weather messages and dissemination methods using multiple library and reference databases (e.g., TRIS, NTIS, INSPEC, COMPENDEX, PSYCINFO, etc.). The sources obtained during the literature searches were augmented by additional sources identified through web searches (e.g., Google). The categories searched and their corresponding set of search terms used is shown in Table 7 below.

In an effort to be as comprehensive as possible, project staff conducted basic internet searches of "comparable domains" that might have been able to provide relevant information to this effort. The goal in doing so was to make sure that any and all relevant and useful information was identified and reviewed. In particular, we were hoping to find existing requirements, guidelines, integrated research reviews, etc. that could provide high-level principles that would be of use to the current project. Several Federal Aviation Administration websites and documents came up during these searches, as did several books and large reports from the more general aviation domain. These data sources were briefly reviewed, but did not yield much information that would be of direct use to this project. In general, these application domains are quite different from the road weather domain, making our use of data from these domains somewhat risky.

Search results containing 72 initial reports were imported into a Procite database and irrelevant articles were culled from the list based on available information, such as titles and abstracts. This resulted in a final list of 51 documents which were added to our master list. All items in the final list were downloaded directly or obtained through Battelle's library services for subsequent review.

Table 7. Initial literature search terms. Note that common synonyms and word stems (e.g., behav* to capture variations of the word behavior) used are not shown in the table.

Term Category	Search Term
Traffic	Traffic, Highway, Roads, Driving, Route
Driver	Driver, Motorist, Trucker, Traveler, Decision-making, Information-needs, Information Requirements, Human Factors, Behavior
Information System/Program	Road Weather Information System (RWIS), Clarus, Aurora, Advanced Transportation Weather Information System (ATWIS), Intelligent Transportation System (ITS), Advanced Traveler Information System (ATIS)
Dissemination Method	TV, Radio, Internet, Kiosks, HAR, 511, Cell phones, Electronic Devices, Mobile devices, In-vehicle Navigation Systems, Satellite Radio
Weather	Weather, Atmospheric, Travel-restrictions, Forecast, Road-closure, Precipitation, Rain, Snow, Fog, Flood, Mist, Wind, Ice, Visibility
Design Guideline	Design Guidelines, Design Specification, Design Guidance, (User) Interface Guidelines

Contacting Relevant State DOT Personnel

We also searched for useful information about weather messages and dissemination methods by directly contacting relevant DOT personnel. Through past road weather projects, Battelle, Texas Transportation Institute, and Meridian have developed close relationships with a variety of states and have knowledge of advisory and control messaging employed by those state agencies. We called a number of these contacts to obtain any documents or other information about road weather messages in actual use in their jurisdictions. We also contacted other DOT personnel to try to provide more diverse regional coverage. The information that was compatible with the database was added. The complete set of information, including the information that could not be incorporated into the database is provided in Appendix A.

Searching DOT Websites

To characterize road-weather information currently available on state DOT websites, we visited all 50 state DOT websites (in addition to District of Columbia website) and cataloged general information about their contents. The following list of information elements was recorded (in a yes/no table format):

- Is there a Daily Weather Update?
- Is a map shown on the weather page?

- Is weather information for specific locations provided?
- Are road weather conditions on Interstate highways provided on a dedicated map or table?
- Are road weather conditions for state, local or other roads provided on a dedicated map or table?
- Does weather information include links to other states or regions?
- Is there a dedicated section to communicate special conditions (e.g., hurricanes, mountain passes, tornadoes)?

Each website was examined to determine if the information was readily available (i.e., easily located on the site), and if so, the table responses were filled in accordingly. Note that the focus was on information that was relatively easy to find by following links from a main weather page, and it is possible that obscurely-located information was missed.

In addition to the table information, a screen capture of one or more key pages for each website was collected and included with the website review. Due to the extensive variation in content and format of the various state DOT websites, the type of webpage that was included as a screen capture also varied. The criteria for determining which page to include in the review were based on the focus of the DOT's primary information page. In some cases, the key page was the 511 traveler information or main road condition/weather information page. In other cases, the key page was an overview or entry page that provided several links leading to road weather information. For some websites, a second key page was captured that illustrates the actual weather information page (e.g., 511 traveler information page). Figure 1 illustrates an example of a website review, which includes the name of the state DOT, the address or addresses of the websites shown in the included screen capture(s), and the elements associated with the listed questions.

State DOT Website Weather Information

State DOT: Alaska (ADOT)

Website Address: http://511.alaska.gov/

Website Information

Yes	No	
x		Is there a Daily Weather Update?
x		Is a map shown on the weather page?
	x	Is weather information for specific locations provided?
x		Are road weather conditions on Interstate highways provided on a dedicated map or table?
x		Are road weather conditions for state, local or other roads provided on a dedicated map or table?
x		Does weather information include links to other states or regions?
	x	Are special conditions noted (e.g., hurricanes, snow, tornadoes)?

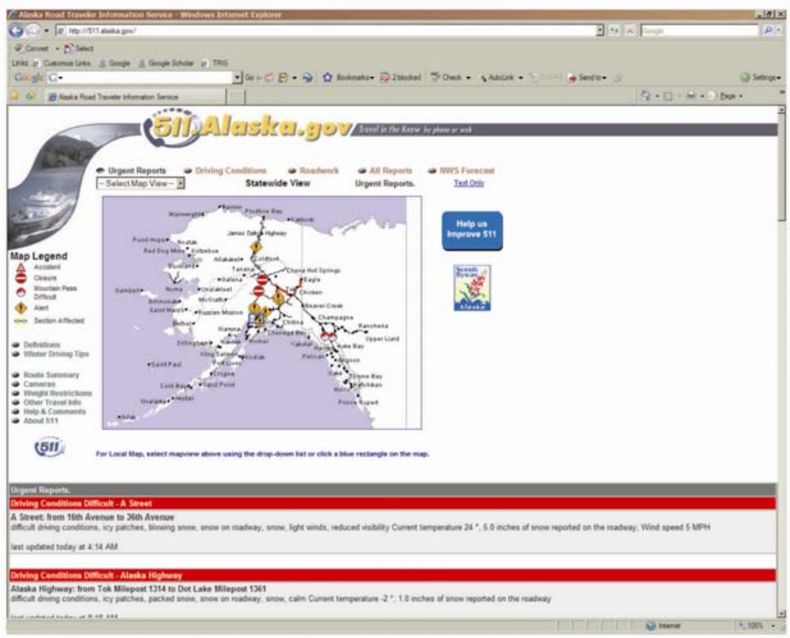


Figure 1. Example of a website review.

Develop Weather Message Database

Literature reviews results were recorded and stored in a dedicated road weather message database using Microsoft Access. Note that this database is provided separately and that this section represents a summary of the database contents.

Document reviewers used summary forms to enter relevant information into the database, which included checkboxes for key information elements related to weather event messages, dissemination methods, message modality, message type, and additional information (see Figure 2). Text input fields were provided for reviewers to list the American Psychological Association (APA) source citation, to describe the article contents, and to provide additional comments. Review instructions were developed and distributed to all reviewers to ensure that all information was being handled the same way.

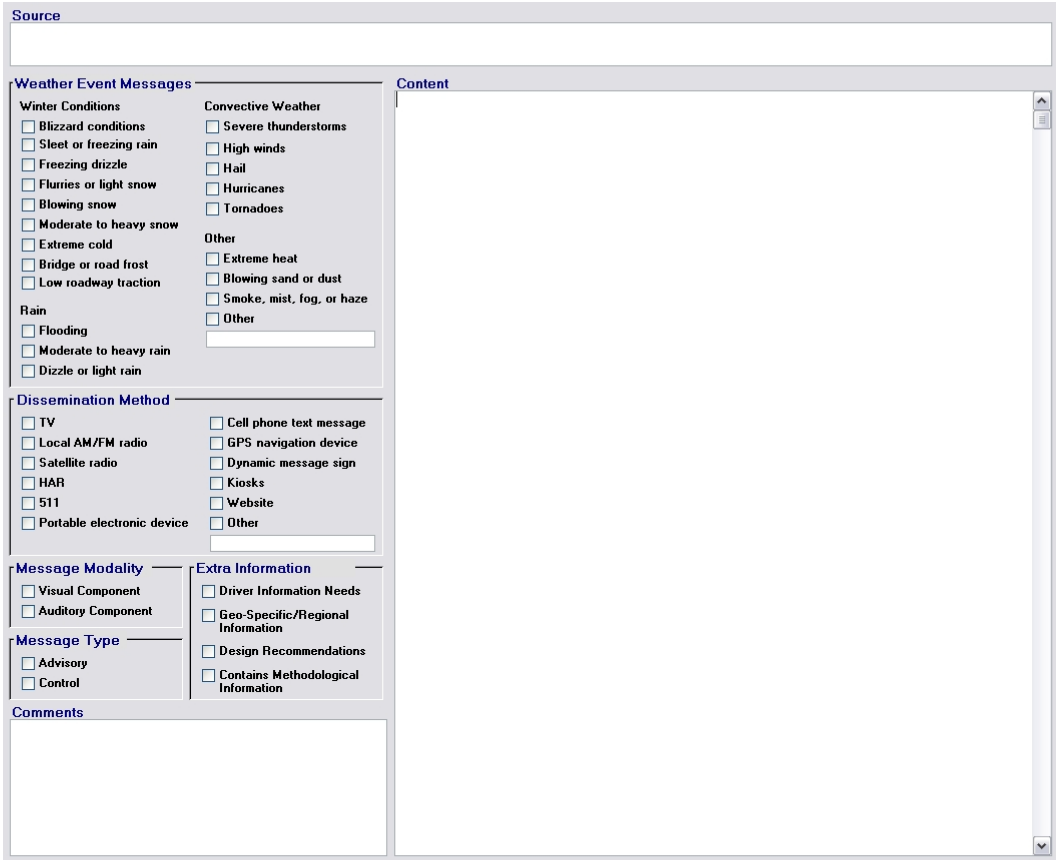


Figure 2. Document review entry form.

To reduce development time and prevent delays, the reviewer database was initially developed as a basic data input tool. A separate, augmented master database was subsequently developed; this master database was structured to be used as an analysis tool. Once the reviews were completed, the data from each of the individual reviewer databases were combined into the master database, and a Visual Basic macro was used to populate tables in the master database with the data from the text boxes and individual checkboxes in the reviewer database. Each checkbox in the reviewer database table was coded with a unique number that was entered into records in a new table in the master analysis database. A lookup table provided textual descriptions of the coded values in the new table. The new table was used to perform queries and generate the analysis reports.

Two reports were generated that summarize the articles reviewed. The first report provides a summary of the number of sources that contain information about weather events, dissemination methods, message type, message modality, and other information. Table 8 provides further descriptions of each of these report components. The second report, organized by weather event message type, lists the citations of all the reports that contain weather event message information.

Table 8. Description of summary report components.

Report Component	Description
Sources Containing Weather Events	Number of articles reviewed that contain Weather Event messages. Organized by weather event category and weather event type.
Sources Containing Dissemination Methods	Number of articles reviewed that describe dissemination methods. Organized by method.
Message Type Counts	Number of articles reviewed that provide advisory and/or control messages
Message Modality Counts	Number of articles reviewed that provide auditory and/or visual message components
Sources that Contain Extra Information	Number of articles reviewed that contain additional information related to driver information needs, geo-specific or regional information, design recommendations, or methodological information.

Summarize Existing Knowledge Related to Candidate Research Methodologies from Ongoing/Completed Studies

The project team reviewed and summarized documents that involved empirical or analytical studies related to the quality, usefulness, and effectiveness of road weather-related messages and dissemination methods. Structured review forms were used to summarize the key information from these research sources. A particular focus was on documenting the methodological approach used in these studies so that the advantages and disadvantages of various methodological approaches could be evaluated.

Some of the questions pertaining to road weather information needs that were addressed included:

- What types of studies have been conducted?
- What weather events and dissemination methods have been examined?
- What topics or aspects of information needs do the studies address?

An overview of this activity is shown in Figure 3.

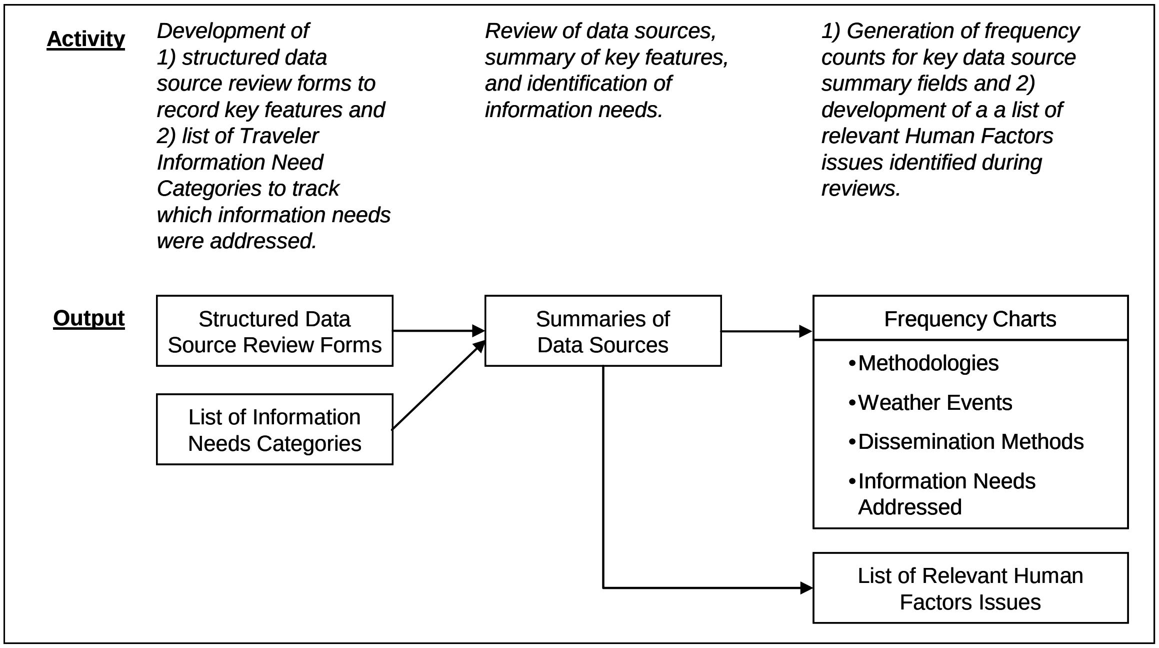


Figure 3. Overview of activities for summarizing existing knowledge.

Data sources obtained during traveler requirements identification served as the focus of the document reviews. Research articles were reviewed and summarized using a document summary template. A new data source summary review form was created for each unique data source examined. If the same study resulted in multiple reports (e.g., conference presentation, Government report, journal article), then the most detailed source available was used. The data fields contained in each data source summary review form are shown in Table 9 below. Completed data source summary forms for all documents reviewed are provided in Appendix B.

Table 9. Fields used to summarize research documents.

Data Field	Description
Document Reference	The document reference.
Study Type	Type of study or studies conducted. One or more of the following: Laboratory Study, Field Study, Survey, Focus Group, or Analytical Study.
Dissemination Methods	Types of dissemination method covered in the study. The term "Multiple" was used if a large range of dissemination methods was addressed.
Weather Impacts/Conditions	Weather conditions addressed by the study. The term "General" was used if there was no particular weather condition covered, or if it was a document from a different domain.
Study Objectives	Brief description of the objective of the study or report, typically using words taken from the document where possible.
General Approach	A one-sentence description of the general approach used and research question addressed.
Methods	Summary and specific details related to the methods used in the study.
Findings	Summary of key findings and conclusions related to driver information needs or weather messages.
Evaluation	A summary evaluation of the methodological soundness of the study, where applicable. This field was also used to highlight the advantages or disadvantages of a particular methodological approach.

Completed summary forms and the original data sources were also evaluated to generally characterize the information that each contained about driver information needs. These additional fields are shown in Table 10. If one of these information elements was covered in a data source, then it was counted. Note, however, that our criterion for counting the occurrence of one of these fields was low, and also did not take into account the quality of the information provided. In several data sources, the information provided is likely to be of limited use because of methodological shortcomings.

Table 10. Descriptions of the data fields tabulated from the research sources reviewed.

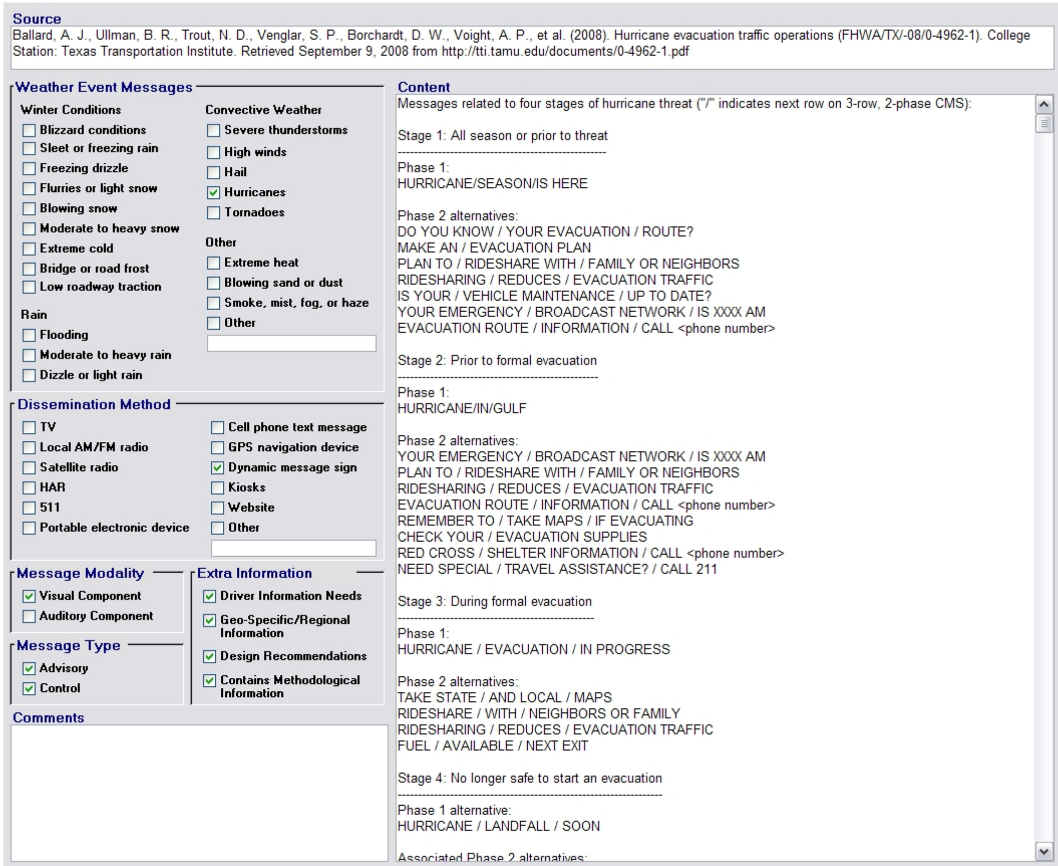
Data Field	Description
Travel Decisions	Information about the specific travel decisions that drivers make.
Info Access Points	Information about when during their travel (e.g., trip planning, en-route, etc.) that drivers want to receive/access road weather information.
System Trust	Information related to data accuracy or how credible drivers perceive road weather information to be.
Method Preference	Information about the dissemination method that drivers prefer under certain conditions.
Information Preferences	Information about the type or scope of information that drivers want a dissemination method to provide.
Design Principles	Information about general design principles or concepts that can be applied to message development across multiple dissemination methods.
Display Principles	Information about general display principles or concepts that can be applied to message presentation or format that is applicable to multiple dissemination methods.
Specific Message Design	Information about the wording or content of a message related to a specific weather event and dissemination method.
Specific Message Presentation	Information about the presentation and/or format of a message for to a specific weather event and dissemination method.

Results

Analyze Road Weather Message Data Base

A total of 47 of the information sources from the Master list contained information that qualified for inclusion in the Weather Message Database. Of this set, 25 had weather message information. Not all of the database entries had weather message information as some were included because they provide useful information for upcoming project tasks.

Figures 4 and 5 below provide examples of what some of the more detailed weather message entries look like. The specific weather messages and other related information is represented as text on the right- hand side, and details about weather message events, dissemination methods, modality, and type covered by the road weather message information are contained in the check boxes on the left.



Source
Ballard, A. J., Ullman, B. R., Trout, N. D., Venglar, S. P., Borchardt, D. W., Voight, A. P., et al. (2008). Hurricane evacuation traffic operations (FHWA/TX/-08/0-4962-1). College Station: Texas Transportation Institute. Retrieved September 9, 2008 from http://tti.tamu.edu/documents/0-4962-1.pdf

Weather Event Messages

Winter Conditions
- [ ] Blizzard conditions
- [ ] Sleet or freezing rain
- [ ] Freezing drizzle
- [ ] Flurries or light snow
- [ ] Blowing snow
- [ ] Moderate to heavy snow
- [ ] Extreme cold
- [ ] Bridge or road frost
- [ ] Low roadway traction

Rain
- [ ] Flooding
- [ ] Moderate to heavy rain
- [ ] Dizzle or light rain

Convective Weather
- [ ] Severe thunderstorms
- [ ] High winds
- [ ] Hail
- [x] Hurricanes
- [ ] Tornadoes

Other
- [ ] Extreme heat
- [ ] Blowing sand or dust
- [ ] Smoke, mist, fog, or haze
- [ ] Other

Dissemination Method
- [ ] TV
- [ ] Local AM/FM radio
- [ ] Satellite radio
- [ ] HAR
- [ ] 511
- [ ] Portable electronic device
- [ ] Cell phone text message
- [ ] GPS navigation device
- [x] Dynamic message sign
- [ ] Kiosks
- [ ] Website
- [ ] Other

Message Modality
- [x] Visual Component
- [ ] Auditory Component

Message Type
- [x] Advisory
- [x] Control

Extra Information
- [x] Driver Information Needs
- [x] Geo-Specific/Regional Information
- [x] Design Recommendations
- [x] Contains Methodological Information

Comments

Content
Messages related to four stages of hurricane threat ("/" indicates next row on 3-row, 2-phase CMS):

Stage 1: All season or prior to threat

Phase 1:
HURRICANE/SEASON/IS HERE

Phase 2 alternatives:
DO YOU KNOW / YOUR EVACUATION / ROUTE?
MAKE AN / EVACUATION PLAN
PLAN TO / RIDESHARE WITH / FAMILY OR NEIGHBORS
RIDESHARING / REDUCES / EVACUATION TRAFFIC
IS YOUR / VEHICLE MAINTENANCE / UP TO DATE?
YOUR EMERGENCY / BROADCAST NETWORK / IS XXXX AM
EVACUATION ROUTE / INFORMATION / CALL <phone number>

Stage 2: Prior to formal evacuation

Phase 1:
HURRICANE/IN/GULF

Phase 2 alternatives:
YOUR EMERGENCY / BROADCAST NETWORK / IS XXXX AM
PLAN TO / RIDESHARE WITH / FAMILY OR NEIGHBORS
RIDESHARING / REDUCES / EVACUATION TRAFFIC
EVACUATION ROUTE / INFORMATION / CALL <phone number>
REMEMBER TO / TAKE MAPS / IF EVACUATING
CHECK YOUR / EVACUATION SUPPLIES
RED CROSS / SHELTER INFORMATION / CALL <phone number>
NEED SPECIAL / TRAVEL ASSISTANCE? / CALL 211

Stage 3: During formal evacuation

Phase 1:
HURRICANE / EVACUATION / IN PROGRESS

Phase 2 alternatives:
TAKE STATE / AND LOCAL / MAPS
RIDESHARE / WITH / NEIGHBORS OR FAMILY
RIDESHARING / REDUCES / EVACUATION TRAFFIC
FUEL / AVAILABLE / NEXT EXIT

Stage 4: No longer safe to start an evacuation

Phase 1 alternative:
HURRICANE / LANDFALL / SOON

Associated Phase 2 alternatives:

Figure 4. Example of a completed entry for a document containing DMS messages.

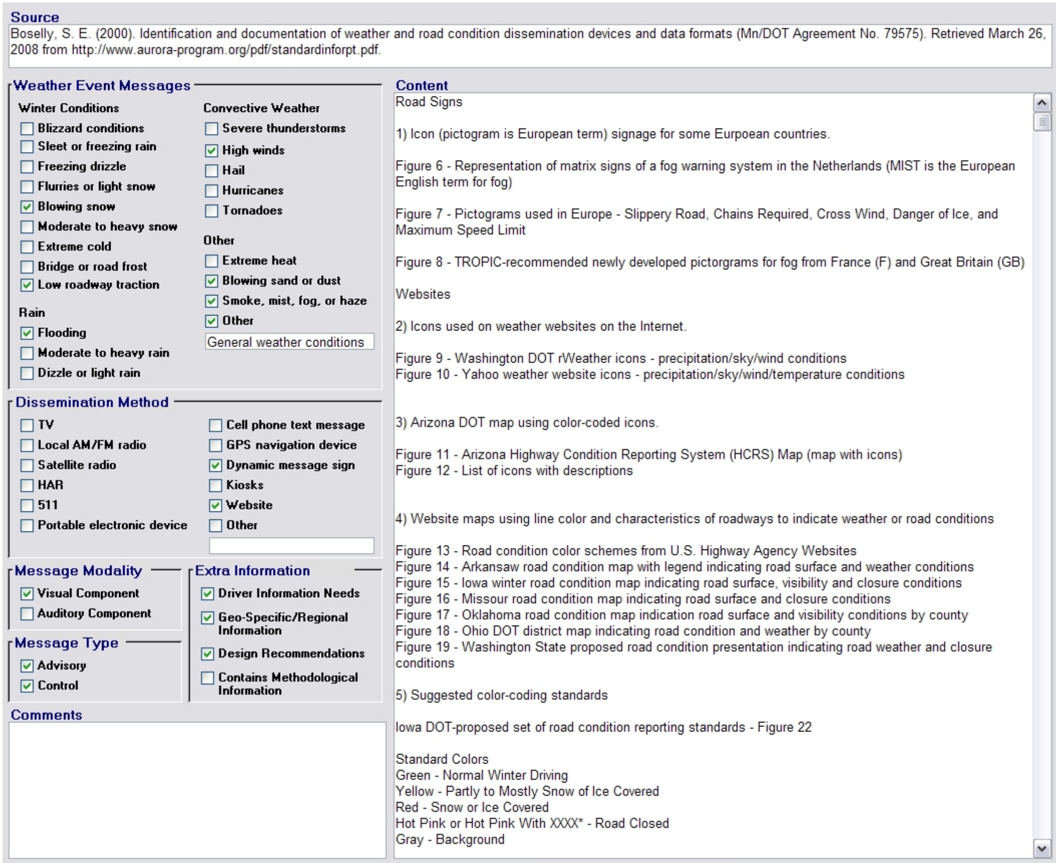


Figure 5. Example of a completed entry for a document containing information about web- and graphic-based presentation of road weather information.

Summary of Available Road Weather Information

The following paragraphs provide a brief summary of the scope of the road weather information available in the right-side descriptive text field from database entries. In general, there was a great deal of specific road weather message information for DMSs, and a limited amount of useful message information related to 511, website, and road signs. There was minimal message information specific to other dissemination methods; however, message information for the dissemination methods listed below is applicable to other methods in many cases.

DMSs

Several documents provided recommended and example DMS messages for various weather events (Ballard et al, 2008; Balke et al., 2007; Boselly, 2000; Dudek, et al., 2006; Ullman, Dudek, Trout, & Schoeneman, 2005). Also, comprehensive lists of DMS messages were obtained from several states through personal contacts (e.g., WA, NV, OR, IA, & UT). Some documents also contained general design guidance and information related to using dynamic features of DMS to display messages (Dudek, 2004; Dudek, Schrock, & Ullman, 2005).

511

There was one document containing an example script messages for #SAFE (University of North Dakota Surface Transportation Weather Research Center, 2006). Otherwise most of the information available about 511 messages came from work conducted by the 511 Deployment Coalition. This included general guidelines on content and design of 511 travel information, including road weather messages (511 Deployment Coalition. 2005), and recommendations for the types of weather content to be presented on 511 systems (511 Deployment Coalition, 2003)

Websites

The information for website communication is fragmented, and most cover just specific elements of website design. One document, summarizes weather icon examples from DOT and Commercial weather sites, such as Yahoo.com, in addition to example color coding schemes for different road conditions (Boselly, 2000). Other documents provide graphics for representing winter conditions and mountain passes in particular (Kajiya, Suzuki, Matsuzawa, & Uemura, 2004; Kajiya, Yasuaki, & Matshushima, 2008). However, the message information from these documents was designed for Japanese drivers, so it will require further investigation to determine how well this information can be generalized to US drivers.

Road Sign Icons

The database contains some limited information about road sign icons used in European countries (Boselly, 2000), in addition to a few examples of highway road weather advisory signage (Corbett, 2007).

General

In addition to the information that is tied to the specific dissemination methods listed above, the database also contains more general information that applies to a variety of methods. This includes a taxonomy of icons for presenting road weather messages (Campbell et al. 2004), which is applicable to websites, television reports, and roadside signage. One document also provides some example message content that can be applied to multiple dissemination methods, such as kiosks, DMS, HAR, 511, or websites (Osborne et al., 2005).

Summary of Check-box Data

In order to provide an overview of the information contained in the database, we computed summary information of the “checkbox” fields contained on the left side of the review forms. Note that the totals provide a generous accounting of the actual amount of information because the criterion for checking a box was low. As long as weather message information pertained to a check-box item, it could be checked. Also, several messages were relevant to multiple check-box items, and all associated boxes were checked in these cases. Nevertheless, the summary tables below still provide a general summary of what information elements are covered by the available weather messages.

The tables in the following section provide totals for each checkbox in the following categories:

- Weather event messages

- Dissemination methods
- Message modality and type
- Other information

The Frequency column indicates the number of entries that had a particular box checked. Note that because single entries could contain information about multiple checkbox items, combined totals/subtotals can exceed the number of database entries.

Weather Event Messages

Table 11 indicates the number of documents/database entries that contained weather message information for each type of weather event listed. The table is divided into four sections that are classified by weather event: 1) winter conditions, 2) rain conditions, 3) convective weather, and 4) other events. Additionally, some documents contained message information about events that were not included in the *Weather Event Messages* group of checkboxes but were added as "Other" information. These weather events were folded into the table.

Table 11. Weather event messages.

Frequency	Winter Conditions
2	Freezing Drizzle or Fog
5	Blizzard Conditions
6	Blowing Snow
6	Bridge or Road Frost
2	Extreme Cold
4	Flurries or Light Snow
14	Low Roadway Traction
5	Moderate to Heavy Snow
3	Sleet or Freezing Rain
47	Subtotal
2	Moderate to Heavy Rain
1	Drizzle or Light Rain
11	Flooding
14	Subtotal

Frequency	Convective Weather
2	Tornadoes
3	Severe Thunderstorms
8	Hurricanes
1	High Winds
2	Hail
16	Subtotal
5	Extreme Heat
13	Blowing Sand or Dust
1	Smoke, Mist, Fog, or Haze
3	Limited Visibility
4	High Ozone Conditions
5	General Weather Events
31	Subtotal

Dissemination Methods

Table 12 indicates the number of documents/database entries that contained weather message information for each type of dissemination method listed. Additionally, some documents contained message information about events that were not included in the *Dissemination*

Methods group of checkboxes but were added as "Other" information. These additional dissemination methods were folded into the table.

Table 12. Dissemination methods.

Frequency	Method
11	Website
3	Portable electronic device
5	HAR
3	GPS navigation device
1	Local AM/FM radio
6	511
22	Dynamic message sign*
2	Permanent Road Sign**
2	In-vehicle Display
3	Kiosk
58	Total

* Two DMSs included a flashing light to improve conspicuity.
** One permanent road sign included a flashing light to improve conspicuity.

Message Modality and Message Type

Message modality refers to whether the message is presented through the visual channel, the auditory channel, or both. Checkboxes were provided to indicate the modality of the weather messages identified in a document. Messages that were identified as being presented with both visual and auditory components received checkmarks in both categories to indicate that the *Content* field contains information about modality.

Message type refers to whether the message provides advisory information (e.g., "Fog Conditions When Flashing" or "Wet Pavement Ahead" or control information (e.g., "Extreme Wind Warning—Seek Shelter Now" or "Chains Required Ahead"). The appropriate box was checked to indicate that the *Content* field contains information about advisory messages, control messages, or both. Table 13 summarizes the number of sources that describe the modality of the message presentation and also the message type.

Table 13. Message modality and message type.

Frequency	Modality
10	Auditory
29	Visual
39	Total
Count	**Message Type**
16	Control
30	Advisory
46	Total

Additional Information

Four checkboxes were included on the input form to indicate whether the sources contained information that may be useful in later project tasks. A check was placed in the checkbox to indicate that the source contained specific information about the following aspects:

- Geo-specific information
- Driver information needs
- Information relevant to methodological review described later in this chapter
- Design recommendations

Table 14 provides summary counts of the sources that contain additional information.

Table 14. Additional information.

Frequency	Information
12	Contains geo-specific information
22	Contains driver information needs
21	Contains methodological information
12	Contains design recommendations
67	Total

Summary of Documents Covering Traveler Information Needs

As indicated in Table 14 above, 22 documents were identified as potentially containing information relevant to traveler information needs. These documents were reviewed in further detail, and we found that a much smaller set of these documents actually provided more than just superficial information about traveler information needs. The key findings from this core set of documents are summarized below based on which aspects (e.g., content, dissemination method, etc) of traveler information needs they address.

Content

Two documents included user preference surveys that examined the type of weather information that travelers would like to see included in traffic messages (Lappin, 2000b; Hansen, Martin, Perrin, & Meldrum, 2001). For example, one of these studies found that drivers preferred information about road conditions that inhibited vehicle performance (i.e., accumulating snow, fog, ice, wind, road closures) over information on alternate routes, travel times, or travel speeds, and over information about more benign types of weather events (e.g., rain, non-sticking snow, thunderstorms, snow flurries, etc.; Hansen, et al., 2001). Another document provides a discussion of the uses of weather information, including a high-level evaluation of information currently provided versus information needs identified based on surveys, symposiums, and workshops with transportation agencies and other industry sectors (Office of the Federal Coordinator for Meteorological Services and Supporting Research, 2002). Note, however, that the primary focus of this document is on all surface transportation modes, and very little of the content is directly focused on highway safety.

Dissemination Method

One document presented the results of a traveler survey focused on determining the roadway weather information requirements of travelers in Utah (Hansen, et al., 2001). The survey focused on user preferences regarding the type of weather-related information they like to obtain, as well as their preferred approaches for obtaining the information. This study found that the most popular dissemination methods included DMS, commercial radio, and HAR.

Presentation

Several documents described focus group and survey efforts that investigated traveler preferences regarding presentation of weather information (e.g., Ballard et al., 2008; Boselly, 2000; Dudek et al., 2006; Hansen et al, 2001; Ullman et al., 2005; etc.) . Presentation elements that were evaluated included message wording, word order, color, icons, etc. Another study investigated the usability of statewide web-based traveler information systems to assess their effectiveness in conveying weather information to travelers (Fayish & Jovanis, 2004). The study used subjective ratings of message elements to evaluate the websites based on criteria of relevance, ease of use, ease of access, timeliness, coverage, and accuracy.

Other Empirical Research

Two studies provided data showing that driving performance can be improved by presenting weather-related warnings under adverse weather conditions. For example, one driving simulator study showed reductions in driver speed as a result of exposure to fog advisory (with speed limit) messages on a DMS (Kolisetty et al., 2006). Also, a literature review cited studies in which speed reductions were achieved in fog and icy road conditions in Europe when drivers were presented with weather-based variable speed-limit signs (Smith, 2001). While these types of empirical studies have the potential to provide useful information about effective communication approaches, it turns out that the specific research articles reviewed here are not very useful in this regard. More specifically, their findings that presenting road weather warnings is better than not presenting warnings is not as useful as information about which presentation/communication approaches are more effective than others.

Overall, the existing information on traveler information needs is limited. There is reasonably good information about traveler preferences. This is relevant for identifying information needs related to how and when drivers prefer to access information, which is useful because travelers will be more likely to seek out and use information if it is presented using the methods they are most comfortable with. However, what drivers want and what they need are not always the same. In particular, this preference-type information does not provide a complete picture of the factors that underlie specific travel decisions, nor does it provide information about what approaches are most effective for helping drivers understand and act on road weather information (e.g., optimal presentation formats/characteristics). Performance-based data are suitable for answering these questions, however, the empirical studies reviewed in this section did not investigate these issues at the necessary level of detail. We also need more information covering a broader range of dissemination approaches. There is some information about methods such as websites, DMS, and 511, but much less for other approaches. In sum, the current review indicated that we will require much more information about traveler information needs from other sources or activities before we can make substantive progress on upcoming project tasks, such as guidelines covered in Chapter 5.

Obtain Information from State DOTs

The results from the DOT website content analysis are summarized in Table 15. The table shows the number and percent of all 51 DOT websites that contained the information elements shown as questions in the left-most column. Results for individual states are provided at the end of Appendix A.

Table 15. Summary of state website information elements.

Information Element	Number Affirmative	Percent Affirmative
Is there a Daily Weather Update?	23	45%
Is a map shown on the weather page?	28	55%
Is weather information for specific locations provided?	29	57%
Are road weather conditions on Interstate highways provided on a dedicated map or table?	35	69%
Are road weather conditions for state, local or other roads provided on a dedicated map or table?	35	69%
Does weather information include links to other states or regions?	14	27%
Are special conditions noted (e.g., hurricanes, snow, tornadoes)?	7	14%

This phase of the project also provided—through an Access© database—useful information about content, format, and dissemination methods associated with existing weather messages. This database has been provided to the FHWA as a separate deliverable.

In total, 29 data sources were reviewed and summarized in this task. Four of these data sources did not provide any information that could be used in the current activity and were excluded from subsequent analyses.

Summarize Existing Knowledge Related to Candidate Research Methodologies from Ongoing/Completed Studies

The objective of this activity was to identify methodological approaches that have been used to investigate travelers' use of weather information, and describe what type of information each of these studies can provide. This information was needed to identify candidate research approaches for a data collection activities conducted in later project phases (see Chapter 4).

Frequency counts of specific information fields served as the basis for addressing the questions posed in the introduction of this task. These questions included:

- What types of studies have been conducted?
- What weather events and dissemination methods have been examined?
- What topics or aspects of information needs do the studies address?

The results associated with each of these questions are described in the following sections.

What types of studies have been conducted?

The most common type of methodological approach reviewed was a Survey (see Figure 6). These surveys included questionnaires mailed out or provided directly to travelers, in addition to web-based surveys targeted at transportation website visitors. Also common were Laboratory Studies. Several of these involved a driving simulator to measure the impacts of accessing information on driving performance, while others involved computer-based presentation of messages that could directly evaluated by participants.

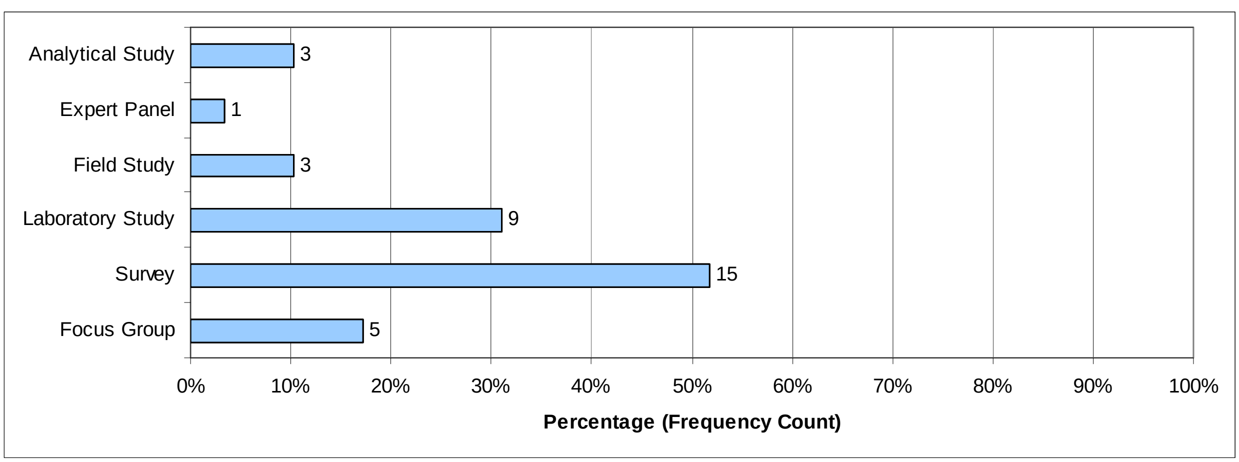


Figure 6. Percent of data sources that employed each type of methodological approach (actual frequency count is shown to the right of the bars).

What weather events and dissemination methods have been examined?

Figure 7 shows the percentage of data sources that addressed each type of weather event. The most common item was the *General* category. This category typically represented studied that were not directly related to road weather information, but still addressed relevant aspects of this topic, such as traveler information needs or weather information in general, without specific reference to a particular weather event. The next most common category was for *Winter Conditions*, which actually represented several different types of weather events, such snow, ice, winter storms, etc. For all other weather events, only one or two data sources were found that contained information relevant to road weather information needs.

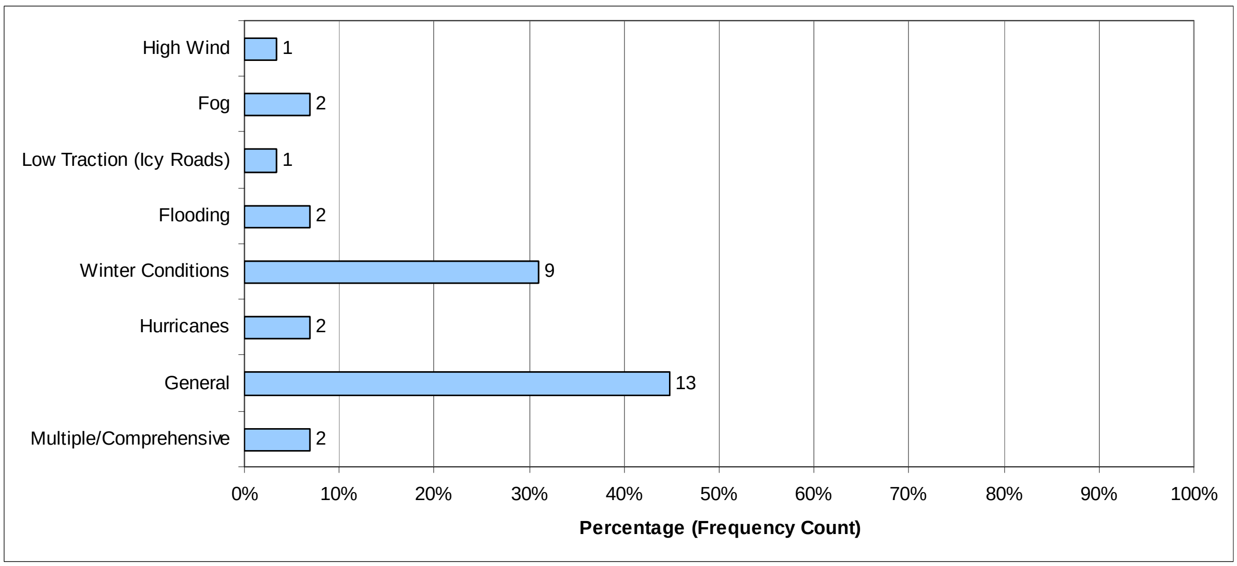


Figure 7. Percent of data sources that addressed each type of weather event (actual frequency count is shown to the right of the bars).

Figure 8 shows the percentage of data sources that addressed each type of dissemination method. Websites and DMSs were the most commonly addressed methods. It should be noted, however, that the information related to technologies that emerged recently, such as websites, personal electronic devices (PEDs), and cellular phone messaging, contain information that is rapidly becoming obsolete due to changes in these technologies over time.

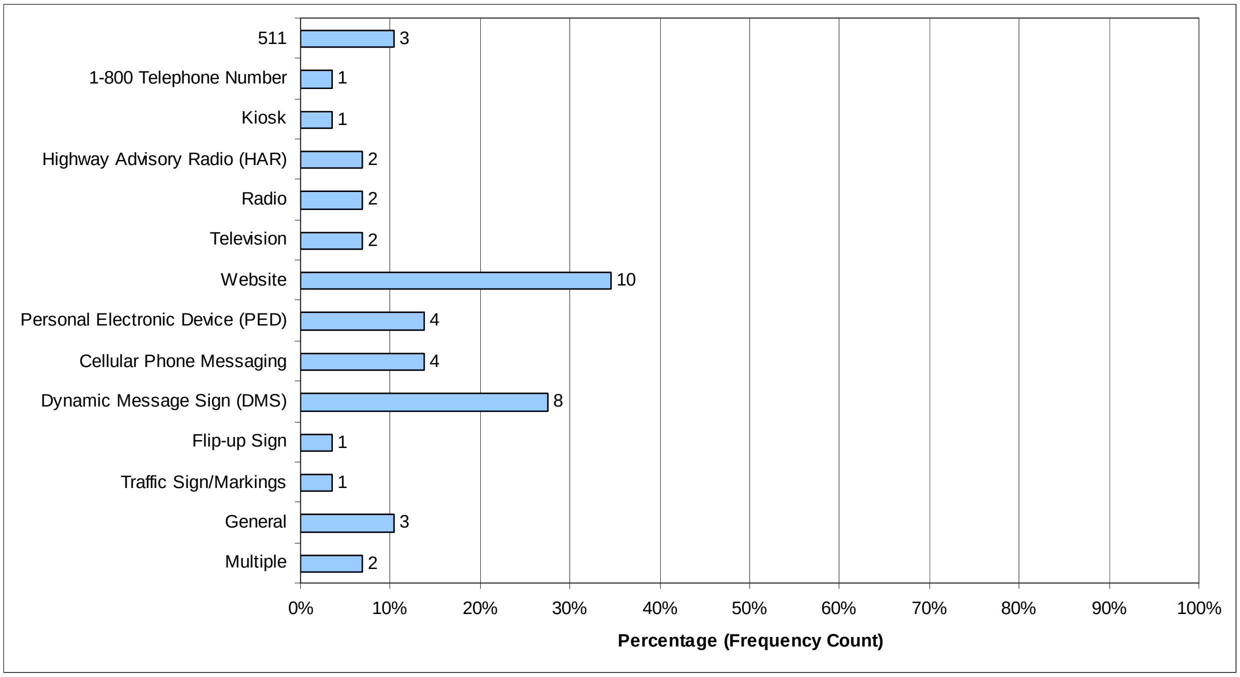


Figure 8. Percent of data sources that addressed each type of dissemination method (actual frequency count is shown to the right of the bars).

Table 16 below provides an overview of the scope of dissemination methods and weather events addressed by the data sources compared to the overall "problem space." The table also indicates the type of study conducted using an abbreviation (e.g., Survey, Focus Group, etc.). Note also that some weather events that were not covered by any of the data sources are not shown in the table. These include: fair/mild conditions, different levels of rain conditions, thunderstorms, and extreme temperatures.

Table 16. Overview of the specific Dissemination Method and Weather Event combinations examined in the research sources.

Data Field	High Wind	Fog	Low Traction (Icy Roads)	Flooding	Winter Conditions	Hurricane	General	Multiple/ Comprehensive
511							L, S	F
1-800 Telephone Number					G			
Kiosk					G			
Highway Advisory Radio (HAR)					S		S	
Radio					G			E
Television					G			E
Website	S		F		S, S, G, S, F, G, S		A, L, S, S	
Personal Electronic Device (PED)		L, S					L, F	
Cellular Phone Messaging					S, F		F, S, S	
Dynamic Message Sign (DMS)	S	L		L, G, G, L	G, L	G, L, L, G	L, L, G, S, L, S, S	
Flip-up Sign	S							
General					S		A, A	
Traffic Sign/Markings						G, L		
Multiple					S		S	

A = Analytical Study
E = Expert Panel
F = Field Study
L = Laboratory Study
S = Survey
G = Focus Group

It is clear from Table 16 that there are significant gaps in terms of the weather event and dissemination method combinations directly addressed by the data sources. Also, the table does not indicate the quality or amount of useful information provided by each study. For the most part, the majority of these studies cover only a few of the many aspects of driver information needs associated with specific weather event and dissemination methods. The exception to this seems to be winter conditions; however, this category represents a multitude of weather events on its own, such as blizzard conditions, frost, different levels of snow, etc.

What topics or aspects of information needs do the studies address?

The extent to which the research sources addressed various aspects of traveler information needs was also counted. Figure 9 shows the percentage of data sources that at least minimally addressed each type of information need. The most common issues covered included specific message design aspects related to the wording or content of messages, in addition to how they are presented or displayed. This reflects the fact that the objective of several of the data sources reviewed was to evaluate existing communication methods or approaches. This information is generally limited in applicability to the specific messages and dissemination methods investigated. Another common issue addressed involved "information preference." This represents the type of information or information elements (e.g., maps, travel time estimates, etc.) that travelers were interested in receiving in a given situation. This information is useful for activities discussed in Chapter 5 and is generally more applicable across dissemination methods and weather events.

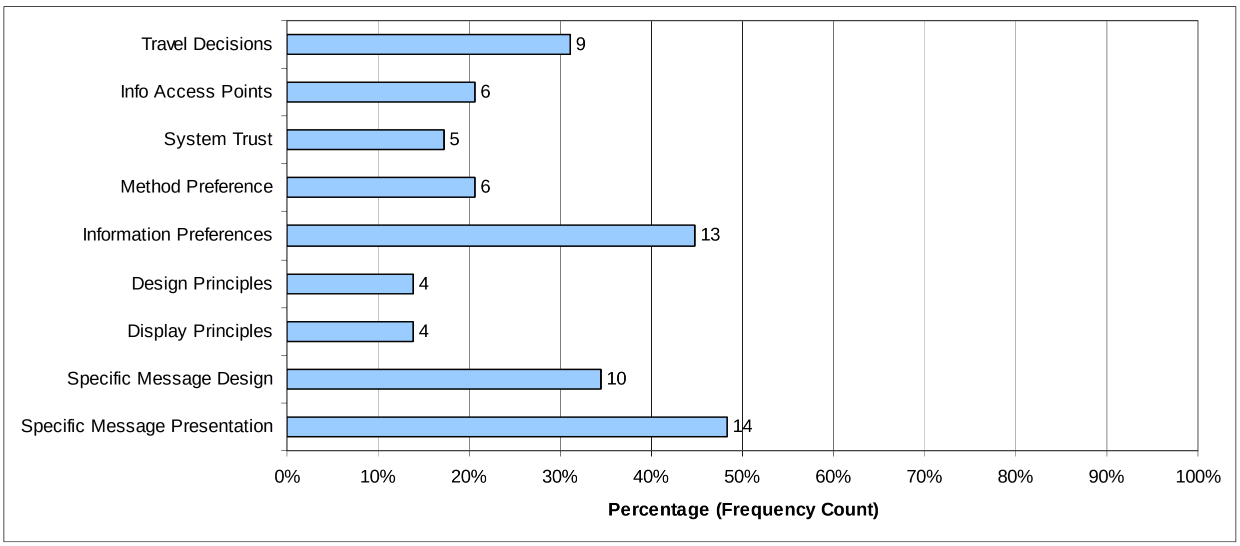


Figure 9. Percent of data sources that addressed each general aspect of traveler information needs (actual frequency count is shown to the right of the bars).

Table 17 illustrates how traveler information needs were addressed across dissemination method and weather event combinations. Note that the information element codes generally become more specific to particular dissemination methods or weather events as the number code increases. Issues relating to traveler information needs have received the most attention for website and DMS dissemination methods and for general winter conditions. However, it is clear from Table 17 that the existing research literature is substantially lacking in terms of the extent to which traveler road weather information needs are understood for various combinations.

Table 17. Overview of the specific research needs addressed by the studies based on Dissemination Method and Weather Event combinations examined. The lower numeric codes correspond to more general types of information needs while the higher numeric codes correspond to more specific ones.

Data Field	High Wind	Fog	Low Traction (Icy Roads)	Flooding	Winter Conditions	Hurricane	General	Multiple/ Comprehensive
511						2, 4, 5, 7		
1-800 Telephone Number					2, 4, 5			
Kiosk					2, 4, 5			
Highway Advisory Radio (HAR)					1, 2, 5, 8, 9		2, 4, 5	
Radio					2, 4, 5			
Television					2, 4, 5			
Website	3, 8, 9		3, 8, 9		1, 1, 1, 1, 2, 2, 4, 5, 5, 5, 5, 5, 8, 8, 8, 9, 9, 9,9		5, 6, 8, 9	
Personal Electronic Device (PED)		3, 9					5, 9, 9	
Cellular Phone Messaging					1, 5, 9		5, 9	
Dynamic Message Sign (DMS)	3, 8, 9			1, 4, 5, 6, 7, 8, 8, 9, 9	1, 2, 4, 4, 5, 5, 6, 7, 8, 8, 9, 9		1, 2, 4, 4, 5, 6, 7, 8, 8, 9, 9	
Flip-up Sign	3, 8, 9							
General					1, 3, 4		1, 1, 2, 2, 3, 5	
Traffic Sign/Markings						5, 6, 7, 8, 9		
Multiple					4, 5		1, 2, 4, 5	

1 = Travel Decisions
2 = Information Access Points
3 = System Trust
4 = Method Preference
5 = Information Preferences
6 = Design Principles
7 = Display Principles
8 = Specific Message Design
9 = Specific Message Presentation

While reviewing the data sources, we also compiled a list of research questions related to traveler information needs that were posed (but not always addressed) by the data sources, in addition to questions identified by the reviewers. This list is not comprehensive; however, it does identify some of the key human factors issues associated with effectively communicating road weather information that will likely have to be addressed during the development of road weather message design recommendations (see Table 18). This list of questions served as a starting point for supporting analytical activities described in Chapter 5.

Table 18. Human factors issues identified during the review of existing research studies described in Chapter 3.

1. What types and sources of weather information are used by drivers in making travel decisions?
2. What types of adjustments do travelers make in light of weather information?
3. What are the safety implications of these adjustments?
4. When can drivers make the best use of information (e.g., trip planning, en-route, etc.)?
5. How soon before a weather event is expected to occur, or how soon prior to leaving for their trip, do travelers want and need information?
6. What types of weather conditions require weather information to preserve driver safety before they get on the road or while they are on the road?
7. What kind of improvements in weather information do travelers need (previously question #4)?
8. How might more or improved weather information be used?
9. What is the value of more or improved weather information?
10. Which Dissemination Methods do different types of travelers prefer?
11. To what extent is drivers' dissemination method preference based on lack of knowledge of what is available?
12. How do driver demographics/characteristics vary based on preference for different dissemination approaches?
13. What factors determine which dissemination method drivers will use to obtain road weather information?
14. How important is trust in the accuracy and reliability of information, and what are the best ways to promote this trust?
15. What phrasing (advisory or control) should be used in various situations?
16. Are visual or audio effects (e.g., sound clip of thunderclap) useful for communicating the degree of severity?
17. When there are more information units than can be displayed, what information units should be displayed?
18. How can the safety impacts of a driver obtaining road weather information while on the road be minimized?
19. For each combination of Weather Condition/Impact and Dissemination Method, what information /specific messages should be presented and how should it be displayed?

CHAPTER 4: EVALUATION OF EXISTING ROAD WEATHER ADVISORY AND CONTROL INFORMATION

The objective of this phase of the project was to conduct a limited a human factors study related to road weather information. This first involved conducting a tradeoff analysis of the candidate methodological approaches identified in Chapter 3, developing a work plan for selected methodological approach, collecting/analyzing data, and summarizing the results.

The tradeoff analysis was conducted first to determine what type of study (e.g., data collection, analytical study, etc.) would provide the most useful information given the limited time and resources available to conduct this work.

Methods

The methodological approaches used in the tradeoff analysis and data collection activities are described below.

Tradeoff Analysis to Select a Methodological Approach

The tradeoff analysis involved five key steps, which are listed below. These steps are not described in detail in this Methods section because the process for conducting the tradeoff analysis is tightly integrated with the results, and consequently, more efficiently presented in the Results section.

1. Organize document summaries based on methodological approach,
2. Summarize what types of research questions are suitable for each approach based on the data source reviews,
3. Propose a set of candidate approaches for the data collection/analysis activity that focus on suitable research questions,
4. Specify relevant criteria for evaluating the candidate approaches, and
5. Compare each approach using a trade-off analysis.

Data Collection/Analytical Activity

One of the primary approaches selected based on the tradeoff analysis was to collect a limited amount of data from travelers using a brief questionnaire. The methodological approach used is described below.

Questionnaire Development

Thirty-four questions were developed and grouped into 16 primary questions (the remainder being sub-questions). Draft questionnaires were submitted to Battelle's Institutional Review

Board (IRB) and the FHWA for review and comment, and we also received feedback on the questionnaire and the protocol from senior Washington State Department of Transportation (WSDOT) personnel associated with Rest Areas[1] and Intelligent Transportation Services. The WSDOT feedback also allowed us to incorporate insights they had gained from their own rest area surveys. Finally, the questionnaire was pilot tested for comprehension, timing, and ease of completion with a small number of drivers. The complete questionnaire is provided in Appendix C.

The questionnaires were designed to obtain information on several different topics. These included:

- Background information, such as demographic information and information about the respondent's current trip
- Travelers' general use of road weather information
- Travelers' use of road weather information during a severe weather event. This section was only completed if respondents reported encountering such an event in the last year. The reason for tying these questions to a specific weather event rather than to a generic, hypothetical weather event was to improve the validity and reliability of the data, even though we would likely gather less data overall because some respondents did not encounter the specified conditions
- Information about how important different types of road weather information are and when travelers find it useful to obtain this information
- Information about traveler familiarity with and use of a variety of dissemination methods

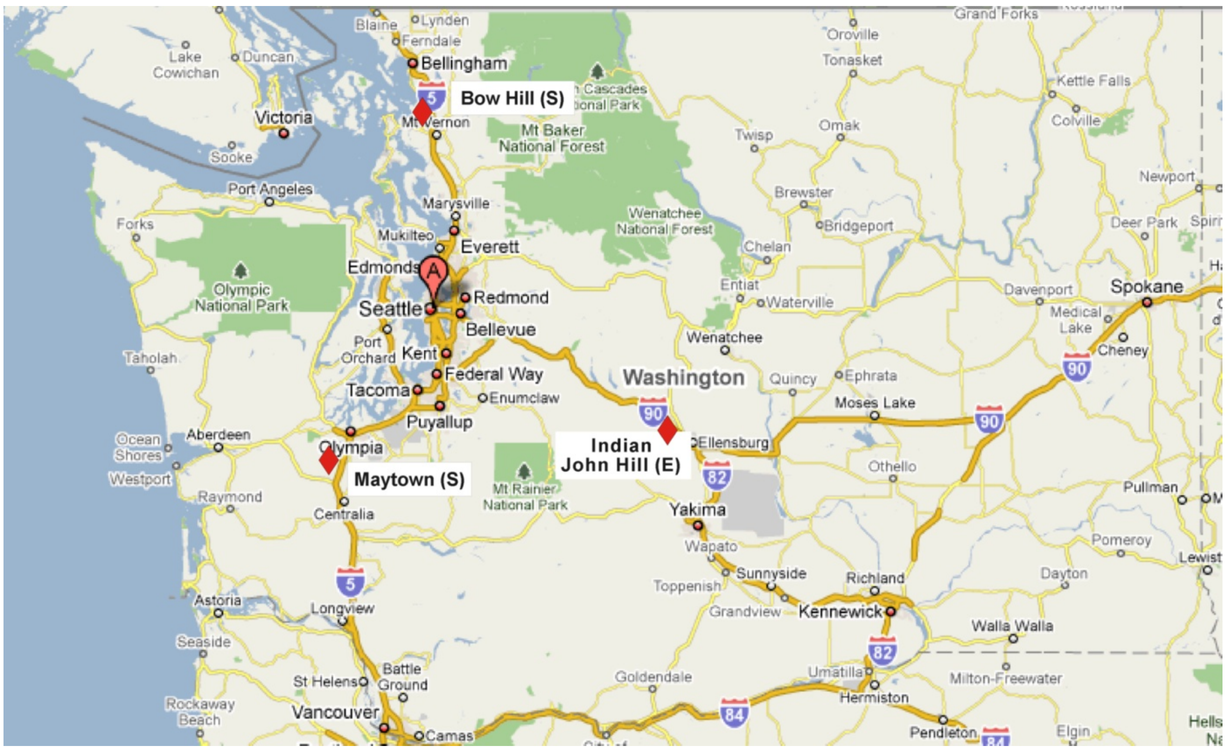
Data Collection Sites

Three rest areas in Washington State were selected for data collection based on consultation with WSDOT personnel. Site selection was guided by the objective of obtaining a representative range of travelers balanced with schedule constraints of the data collection personnel. Given that individual recruitment was done opportunistically based simply on drivers who agreed to participate, it was important to select data collection sites and days that had a good chance of providing a mix of traveler types. Table 19 provides a list of the data collection sites and a description of their key features, and Figure 10 provides a map showing where the data collection sites were located. Because of limited resources available to conduct this activity, data collection was limited to a single day at each location.

[1] Battelle would like to thank Doug Pierce and Bill Legg of WSDOT for making data collection possible and for reviewing the questionnaire and protocol to improve data collection effectiveness.

Table 19. List of data collection sites.

Site	Time Period	Comment
Bow Hill, Southbound I-5	Daytime, midweek	Good location for heavy truck traffic
Indian John Hill, Eastbound	Daytime, midweek	Good location for heavy truck traffic, and personal and recreational travelers making longer trips
Maytown, Southbound I-5	Daytime, weekend	Good time and location for recreational travelers



This figure was created using Google Maps.

Figure 10. Map showing the location of the three data collection sites (red diamonds) with the "A" showing Battelle's Seattle Research Center The letter in parentheses following the site name indicates the rest area's travel direction.

Participants

All participants were adults who volunteered to participate in the study. Across all sites, a total of 92 travelers completed the questionnaire. Participants were approached as they were standing around waiting or heading back to their vehicles. They were given a short description of the study and its objectives and asked if they would like to participate. Travelers who agreed to participate were given the questionnaire on a clipboard to complete on their own. They were also told that they were welcome to ask any questions if there was anything they did not understand or if they needed clarification. Upon completion of the questionnaire, travelers were given a 5-dollar gift card as a thank you for their participation. Researchers tried to avoid respondents from the same household or travelers that could clearly be identified as originating from outside of the U.S. (i.e., based on license plate), however, since we had no formal process for validating this information (due to IRB confidentiality requirements), it is possible that at least a few individuals from these categories are included in the final data set.

Results

The results of the tradeoff analysis are presented below.

Organize Data Source Summaries based on Methodological Approach

In this activity, key data elements from individual data source summaries were aggregated into a table and sorted by *Methodological Approach* type. The key fields included the abbreviated *Document Reference*, *General Approach*, and *Evaluation*. The *Evaluation* field characterized the methodological soundness of the study and highlighted the advantages or disadvantages of a particular methodological approach. It was based on consideration of the data source's assessment criteria, analysis procedures, and findings/conclusions. Summaries from documents that provided no useful information were excluded. Also, other studies that used multiple approaches (e.g., Focus Group and Survey) were given duplicate entries in each corresponding *Methodological Approach* category. Additionally, if the *Evaluation* field information was specific to just a single approach, that information was only included for the entry that corresponded to this methodological approach. Table 20 lists each data source, along with its associated general approach and evaluation comments.

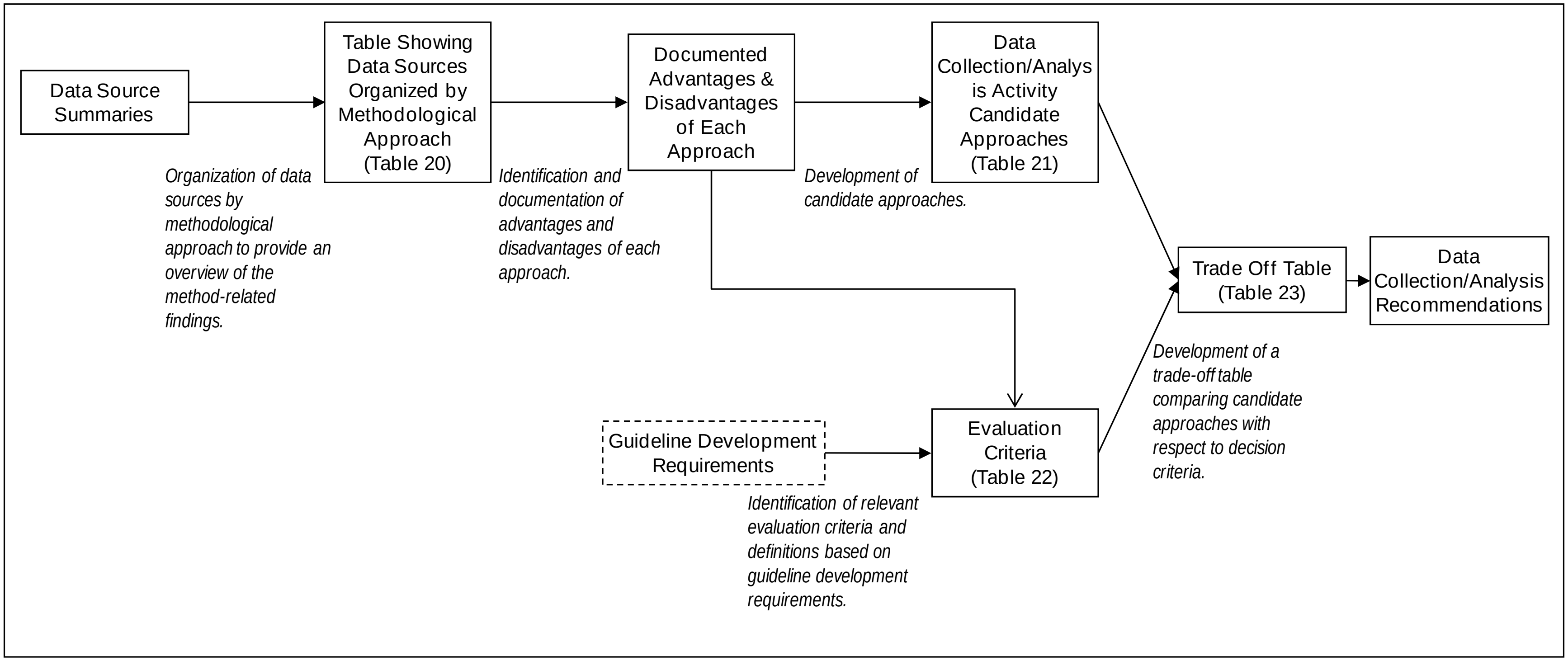


Figure 11. Activities conducted to develop recommended approaches for the data collection/analysis activity described in Chapter 4 (the boxes are organized based on the key outputs).

Table 20. Summary of *General Approach* and *Evaluation* fields from the document summaries, sorted by methodological approach.

Reference	General Approach	Evaluation
	Analytical Study	
Andrey et al., 2001	Selective research reviews related to road weather information needs (among other topics) were conducted, organized by research question.	The article provides some information on a range of important topics related to driver information needs. The amount of methodological information provided is limited and it is unclear how systematic the review was.
Lappin & Bottom, 2001	A literature review was conducted to summarize published research regarding traveler response to real-time information at individual and network levels.	This review provides a good integration of the available information at that time regarding traveler information needs and how they use information. This approach is relatively unstructured, so it difficult to assess how objectively different sources were considered. Overall, it is an effective and generally inexpensive method for extracting key findings and concepts for topics that have a large existing research literature base.
	Focus Groups	
Ballard et al., 2008	Focus groups and laboratory studies involving motorists were used to obtain direct evaluations of evacuation-related signs, traffic control, and information needs.	Focus groups seemed to be effective for identifying a broad range of information requirements and their relative priority. These results, while useful and informative, are not generalizable.
CJ Olson Marketing, 2000	Six focus groups in Minnesota cities were conducted regarding available road condition information systems.	Conclusions about Internet use likely to be out of date, since general Internet use has increased since that time.
Dudek et al., 2006	Focus groups and laboratory studies were used to obtain driver feedback concerning DMS message information needs and potential problems with message understanding and other deficiencies.	A combination of focus groups and laboratory studies was used for identifying key message design elements and evaluating basic yet important aspects of specific messages, such as comprehension.
Kajiya et al., 2004	Questionnaires were administered and a focus group conducted to determine how web-based weather information affects travel choice, traffic safety, and sense of security.	The report provides only general information about the questions asked in the questionnaire, with a few examples of questions asked. However, it does provide some useful information about content, dissemination method, and attitudes about how such an information system should be paid for.
Ullman et al., 2005	Focus group studies were conducted in six cities in Texas to obtain driver needs and attitudes related to various messages to be displayed on DMS. Results from the focus group studies were used as the basis for more extensive laboratory studies.	This report presents detailed methodologies. The study applies to both specific conditions as well as general DMS design principles.

Reference	General Approach	Evaluation
	Laboratory Study	
Ballard et al., 2008	Focus groups and laboratory studies involving motorists were used to obtain direct evaluations of evacuation-related signs, traffic control, and information needs.	The laboratory study provided a visually-accurate method for presenting signs and markings for evaluation. The comparisons between different signage/marking options appear to be valid.
Bhise & Ambeti, 2007	A fixed-based simulator was used to measure driving performance using different information access methods (e.g., touch pad versus voice activation).	This driving simulator approach has limited use for evaluating potential safety impacts of specific aspects of information dissemination approaches (i.e., information access in this case). More subtle aspects of dissemination approach, such as information content, are unlikely to be associated with sufficiently strong impacts on driver performance to make this approach feasible.
Dudek et al., 2005	A driving simulator was used to compare message comprehension and driving performance impacts for three different DMS presentation formats with different dynamic features.	The study provided empirical validation of specific design approaches (i.e., presentation format). The driving performance Measures of Effectiveness (MoEs) may not accurately reflect actual driving performance effects because the display of the DMS was unrealistic (e.g., a static box with constant visual angle) and not integrated with the visual scene.
Dudek et al., 2006	Focus groups and laboratory studies were used to obtain driver feedback concerning DMS message information needs and potential problems with message understanding and other deficiencies.	A combination of focus groups and laboratory studies was used for identifying key message design elements and evaluating basic yet important aspects of specific messages, such as comprehension.
Fayish & Jovanis, 2004	A usability study was conducted to assess how effective a state-wide web-based traveler information system was for conveying road and weather information to travelers.	This approach was effective in obtaining direct information about traveler information needs. It provided information about general website design principles, in addition to feedback about individual websites. However, the particular user population investigated likely limits the generalizability of the results.
Harder & Bloomfield, 2008	A driving simulator was used to measure driver responses to various DMS messages, in combination with a survey approach to obtain driver opinions on a wider variety of message types.	The driving simulator study provided relatively limited information about specific DMS messages relative to the level of effort spent to collect this information. However, the survey did provide empirical validation of specific design approaches (i.e., simple/clear wording) and usable information about how useful drivers perceive various types of messages to be.
Jonsson et al., 2005	A driving simulator was used to measure driving performance and attitude in response to warning messages presented with varying levels of speech message accuracy.	The study was not weather specific; although a fog warning is included in the presented messages, the study focused on general warning messages. Nonetheless, the results are likely to be generalizable to weather messages.

Reference	General Approach	Evaluation
Kolisetty et al., 2006	Participants viewed the same fog warning message on three successive DMS in a driving simulator scenario.	The article provides information about the experiment methodologies, but with the exception of distance between signs, provides no information about the DMS messages, their content, or their presentation.
Stanley et al., 2005	A driving simulator was used to measure driving performance and responses to traffic conflicts while drivers access a 511 system (both hand-held and hands-free access).	This study provides a basic comparison of driving performance under different 511 use conditions. It is difficult to directly extrapolate the safety/crash results to real-world performance because of inherent differences in how drivers approach simulated driving. However, the basic conclusion that situational awareness is degraded by 511 use is likely to be a useful caution. The approach taken in this study is highly specific to a particular implementation and dissemination method, and it requires a high-fidelity implementation of the dissemination method.
Ullman et al., 2005	Focus group studies were conducted in six cities in Texas to obtain driver needs and attitudes related to various messages to be displayed on DMS. Results from the focus group studies were used as the basis for more extensive laboratory studies.	This report presents detailed methodologies. The study applies to both specific conditions as well as general DMS design principles.
	Survey	
Boon & Cluett, 2002	A brief Internet-based survey was used to obtain information from rWeather website visitors.	This appears to be an easy way to obtain information about website user preferences, assuming that the appropriate arrangements can be made with the website providers. There are likely to be issues related to the generalizability of the results based on how participants are recruited.
Cluett, et al. 2004	Interviews and web surveys were used to evaluate the benefits of the Washington State Department of Transportation (WSDOT) HAR system and traveler information and road-weather web pages used by Commercial Vehicle Operators (CVOs) and the driving public in general.	This appeared to be a reasonably effective approach for obtaining opinions of website information users, although the standard caveats regarding generalizability of the sample still hold. There is insufficient methodological information provided about the CVO interviews, however, the information obtained is relevant.
Drobot, 2008	An Internet survey was used to obtain information on respondents' sources, uses, and perception of weather forecasts; their driving decisions related to a particular winter storm; and basic demographic characteristics.	The report provides limited information about drivers' choice of information source. The amount of methodological information provided is limited with very few details about the survey design.

Reference	General Approach	Evaluation
Harder & Bloomfield, 2008	A driving simulator was used to measure driver responses to various DMS messages, in combination with a survey approach to obtain driver opinions on a wider variety of message types.	The driving simulator study provided relatively limited information about specific DMS messages relative to the level of effort spent to collect this information. However, the survey did provide empirical validation of specific design approaches (i.e., simple/clear wording) and usable information about how useful drivers perceive various types of messages to be.
Kajiya et al., 2002	Two studies were conducted: 1) weather information was shared between road agency (e.g., roadwork, traffic regulation, snow removal operations, etc.) administrators via web pages and 2) civilian participants received weather information email messages on their cell phones.	The report provides little detail about the questionnaire that was administered to road agency administrators, and the results are quite broad, indicating only that web-based information was useful and that information sharing is useful.
Kajiya et al., 2004	Questionnaires were administered and a focus group conducted to determine how web-based weather information affects travel choice, traffic safety, and sense of security.	The report provides only general information about the questions asked in the questionnaire, with a few examples of questions asked. However, it does provide some useful information about content, dissemination method, and attitudes about how such an information system should be paid for.
Kajiya et al., 2008	A questionnaire was administered to 301 respondents to determine willingness to change travel behavior based on weather information methods in three forms.	The report provides some insight into weather information content that may influence drivers' travel behavior and effectiveness of presentation methods. The results are based on subjective ratings.
Kumar & Strong, 2006	A motorist survey was conducted with multiple-choice, ordinal ratings, and open-ended questions presented to assess various aspects of the AWWS.	This report contains some limited amount of information related to perceived usefulness and accuracy, presentation, and content, but it is not likely to be highly useful.
Martin et al., 2000	A survey was conducted among different traveler groups (commuters, truckers, recreational travelers, and long-distance travelers) to identify road weather information requirements and preferred dissemination methods.	This study provides very direct information about road-user information requirements. It also provides useful information about the benefits of specifically targeting different traveler groups in addition to strategies for accessing drivers from each group. The technology-specific findings, however, are likely to be out-of-date, given changes in technology-use patterns since the study was conducted.
Motoda et al., 2005	A questionnaire was used to examine end-user reactions to road condition information presented as icons on a website. Information about road weather conditions was phoned-in to a central data-center by taxi drivers selected to participate in this study.	The number of website responses was low and undermines the reliability of the findings. The website traffic analysis, if conducted over a sufficiently long duration may be a useful approach although, in the current study, the instances of acute weather conditions was low.

Reference	General Approach	Evaluation
Patten et al., 2003	Mail-back surveys were distributed to road users.	Although this study is not specifically focused on road weather information, the methodological approach is useful and can be applied. Overall, this approach was effective for obtaining information from a large number of road users and focusing on a specific trip improved the validity of responses.
Peirce & Lappin, 2003	A travel-diary survey was used to record travel information use by participants over a 48-hour period.	The approach used provided specific and representative data on use of traveler information systems. The quality was very high and informative, but it required "piggy-backing" data collection on a more comprehensive large-scale survey.
	Field Study	
Cluett, Jenq, Saleem, 2003	PEDs that provided web-based and text-messaging capabilities related to road-weather information were provided to participants, who were later interviewed about their opinions about using these devices for obtaining road-weather information.	The generalizability of the findings is limited, given the selected participant population and small number of respondents. Also, opinions are likely to be changing as participants become more familiar with the devices.
Kajiya et al., 2002	Two studies were conducted: 1) weather information was shared between road agency (e.g., roadwork, traffic regulation, snow removal operations, etc.) administrators via web pages and 2) civilian participants received weather information email messages on their cell phones.	The Car Commuter Monitoring results contain some information that may be useful in determining methods that are effective at changing drivers' commuting choice in snow conditions. It is unclear whether these results are generalizable to other weather conditions.
	Expert Panel	
OFCMSSR, 2002	Surveys and interviews were used with transportation professionals to identify weather information needs at a national level for several transportation modes.	This appears to be a useful and comprehensive approach for obtaining information about current practices or information needs from the transportation professional's perspective.

Summarize what Types of Research Questions were Suitable for each Approach based on the Data Source Reviews

The general approach and evaluation information provided in Table 20 above were used to identify and document the ways in which various methodological approaches were used to obtain information about traveler information needs. This involved briefly summarizing each methodological approach based on the key advantages and disadvantages identified, in addition to characterizing the suitability of a particular approach for implementation in the data collection/analysis activity. These summaries are provided in the following sections.

Analytical Studies / Literature Reviews

The studies that involved Literature Reviews addressed a range of directly relevant topics and issues. While they only covered a few existing research sources that were directly related to road-weather messages, they were also able to incorporate relevant data from other similar domains. The ATIS review was particularly comprehensive in detail; however, this was only possible because there was already an extensive existing body of research (Lappin & Botttom, 2001). To be useful, a literature review addressing road weather information needs would have to draw much of its information from outside this domain, since there is so little directly pertinent research in this area. An analytical study was a certainly a viable approach for the data collection/analysis activity, however, rather than just a literature review (which has already been conducted in large part in the current project), a more structured approach, such as a literature synthesis may be more effective. This would involve identifying key research questions (i.e., such as Table 18 above), and finding the best available information to answer those questions.

Focus Groups

Our review of the Focus Group studies suggests that focus groups are a reasonable way to obtain detailed information about general traveler information needs, in addition to more specific information about how messages should be worded or what behaviors specific messages might elicit. Also, with some studies, it was possible to recruit focus group participants that had recently been involved in specific and memorable weather events, such as a hurricane evacuation, to obtain more valid situation-specific information. While this approach can provide comprehensive and detailed information, it is not suitable as a reliable “final” source of information because the qualitative information from a few focus groups cannot be reliably generalized to broader populations. Consequently, Focus Group information is more appropriate as a starting point for the development of specific messages that can be more rigorously validated using other empirical approaches, such as laboratory or field studies. A Focus Group study could be conducted as part of the data collection/analysis activity. It would likely involve discussions of general driver information needs in conjunction with discussions that obtain qualitative feedback about specific messages or communication strategies.

Laboratory Study

The Laboratory studies reviewed consisted of three different approaches: usability studies, contextual message presentations, and driving simulator studies. Each of these is described and the relative advantages and disadvantages of each with regard to investigating road weather messages are discussed.

Usability Studies

In these studies, participants are required to complete tasks using a particular dissemination method while their performance is measured, in addition to subjective opinions about various features (e.g., Fayish & Jovanis, 2004). This approach provides useful design information, and it can cover a moderate set of user information needs. The primary limitation is that this information is typically closely tied to a specific dissemination method, although it may be possible to address more than one weather event in a single study. Also, dissemination methods that require minimal driver interaction (e.g., DMSs and HAR) benefit little from this approach. On balance, however, this approach is suitable for the data collection/analysis activity because it can be easily implemented and it can provide specific information about the layout and content of information provided by a specific dissemination method.

Contextual Message Presentations

With this approach, weather messages are presented on a computer screen within a relevant context (e.g., road-side DMS as viewed from the driver's visual perspective) and driver opinions or responses about the sign are obtained (e.g., Ballard et al., 2008). This approach is similar to a usability study, however, it is better suited for obtaining data from a larger participant sample because minimal participant interaction with a message stimulus is required (typically just viewing). It is also similar to some survey approaches, with the key difference being that it is well-suited to dissemination methods in which the presentation of the specific message is important (e.g., road-side information, or audio information). It requires fully developed message sets, and the results will be specific to the dissemination method for the most part, however, the survey/interview aspects of this approach can still be used to obtain more general user requirements information. This approach is suitable for the data collection/analysis activity. As long as it is possible to obtain or develop messages that are sufficiently accurate and detailed, this approach can be implemented to obtained direct feedback on a variety of messages from a relatively large population of drivers.

Driving Simulator

In this type of study, messages are presented during simulated driving and performance is measured (e.g., lane maintenance), and possibly other more global behaviors as well (e.g., route selection). Using a driving simulator to measure impacts on driving performance is likely to be unreliable, however, because of the difficulty in replicating real-world driving conditions, especially when weather effects are important. This approach does a better job with higher level behaviors, such as direct observation of changes in travel route based on road weather information (e.g., Harder & Bloomfield, 2008), however, this is an expensive approach relative to the amount of useful information that can be obtained. For these reasons, this approach is not suitable for the data collection/analysis activity.

Surveys

The Survey studies reviewed consisted of three primary approaches: opportunistic polling of users of a dissemination method, surveys targeted at specific traveler groups or users of particular routes, and daily logs. Each of these is described and the relative advantages and disadvantages of each with regard to investigating road weather information are discussed.

Opportunistic Polling of Users of a Dissemination Method

This approach typically involves coupling a brief questionnaire with direct traveler use of a dissemination method (e.g., asking a random sample of weather website visitors to answer a survey). It can only be used with a few dissemination methods, such as websites, but perhaps at stop-overs near DMSs or HAR installations. When used with websites it can be an inexpensive method to obtain feedback about information needs from users because they respondents are “self-recruiting” since they seek out information using this dissemination method on their own. Also, the users are likely to be familiar with the dissemination method since they were just using it and can provide feedback that accurately represents real experiences with the technology. A key limitation is that it can only be applied to certain dissemination methods and the results are unlikely to generalize to other methods or to drivers that do not typically use that method. On balance, this approach is not suitable for the data collection/analysis activity because of certain technical challenges that increase the risk for not being able to complete this research. In particular, it relies on obtaining cooperation from a road weather website provider and requires potentially complicated programming to implement.

Surveys Targeted at Specific Traveler Groups or Users of Particular Routes

This approach permits targeting of a relevant sample population for whom road weather information was used or would have been relevant to their travel. Survey questions can cover both general user requirements and issues specific to particular dissemination methods and/or weather events. It is also possible to focus on particular weather events or driver types by targeting certain locations for data collection (e.g., a mountain pass, or ski area). Obtaining sufficient data with limited resources could be a problem, however, since a large number of participants could be required for statistical analyses and financial compensation may be needed to obtain a high enough participation rate. Some version of this may be suitable for the data collection/analysis activity. However, using a questionnaire that is broadly distributed to a large number of drivers to complete on their own may be problematic. This is because it may be difficult to properly describe the dissemination methods and travel scenarios that drivers would evaluate, which is critical for obtaining valid and reliable data. An in-person interview variant of this type of survey, however, targeting a smaller more focused population could avoid some of the problems with this approach. Obtaining a large enough sample may still be a problem.

Daily Logs

Obtaining daily logs from a large sample of drivers is a good way to reliably measure general use of various dissemination methods because it captures actual (self-reported) behavior. The key disadvantage, however, is that it is an inefficient method because it is only possible to collect data on information needs and usage patterns from drivers that typically use a dissemination method, which could be a relatively small fraction of actual participants. Unless this approach could be “piggy-backed” on a larger study, as with Peirce and Lapin (2003), it is probably beyond the scope of the data collection/analysis activity activities.

Field Studies

The two field studies examined in the review were not rich sources of information relative to cost of implementation. In general, field studies can be used to obtain highly valid evaluations of dissemination methods because travelers get direct experience using them. However, providing devices in the field is expensive, and the information obtained is highly specific to the dissemination method investigated. For these reasons, the field study approach is not suitable for the data collection/analysis activity and was not considered in subsequent analyses.

Expert Panel

In the single study reviewed that involved an expert panel, the use of this approach resulted in a comprehensive coverage of the intended topics (OFCMSSR, 2002). Unfortunately, road weather information was a very small part of this and little directly applicable information is available from this data source. Also, this approach is unsuitable for the data collection/analysis activity because expert opinions were obtained via either dedicated symposiums (which are more expensive to conduct than the resources available), or through direct contact with participants that had relevant expertise in the area. This latter approach is also problematic because so few researchers are involved in the study of human factors and traveler information needs for road weather information. Subject Matter Experts (SMEs) in more general human factors areas could be involved; however, this would likely not provide any better information than easier-to-implement analytical approaches. For these reasons, the expert panel approach is not suitable for the data collection/analysis activity and was not considered in subsequent analyses.

Propose a Set of Candidate Approaches for the Data Collection/Analysis Activity that Focus on Suitable Research Questions

Based on the summary of the strengths and weaknesses of the various methodological approaches reviewed in Chapter 3, a set of candidate research approaches was developed to serve as a basis for conducting a trade-off evaluation to identify suitable methodological approaches for the data collection/analysis activity.

One assumption that was made for most of the candidate studies was that flooding/high water or heavy snows would be the primary weather event investigated by the empirical studies. While it was not necessary to do so at this point, it allowed us to take advantage of an experimental design aspect that could potentially boost the validity and quality of data obtained using empirical approaches. However, it also led to additional constraints for participant recruitment.

The specific experimental design aspect we are referring to involves taking advantage of participants’ recent experience with memorable weather events, which can allow them to provide more detailed information that possibly reflects their own experiences or actions during these weather events (e.g., Ballard et al., 2008). In the last year, the Seattle area experienced two types of weather events which fall under this category. These include unusually high snowfall levels during the winter holidays and springtime flooding in low-lying areas in the Northern and Eastern Seattle regions.

In the tradeoff analysis, the research approaches were assessed with regard to their suitability for implementation in the data collection/analysis activity. For the approaches that were deemed to be suitable, details about potential candidate approaches were developed so that they could be evaluated using the trade-off process. The candidate approaches are presented in Table 21, in addition to some basic information about the expected participants, general approach, and likely scope of the findings.

Table 21. Candidate research approaches.

Study Type	Partici-pants	Dissemi-nation Methods	Weather Events	General Approach	Scope of Findings
Analytical Study	None	Several	Several	A literature synthesis would be conducted that would draw on empirical findings from other related domains to provide information about key information needs questions. Expert judgment will be used to apply established and reliable findings to road weather information needs.	High-level information needs, specific issues addressed in other domains (e.g., system trust), and application of general design principles (e.g., recommended number of message units).
Focus Groups	3-4 groups of 10-15 drivers that live in flooded areas	1-3 different methods	Flooding	Focus Groups would be divided into 2 parts. The first would obtain qualitative information about general information needs during flooding. The second part would present detailed descriptions of dissemination methods to participants; they would provide technology/message-specific feedback about the communication process and messages.	Detailed qualitative data about information needs related to a specific weather event. Detailed qualitative feedback on how drivers would expect to use various dissemination methods and what information they would want.
Laboratory Study	20-30 drivers that live in areas that flooded	1-2 different methods	1-3 Flooding, Heavy Rain, Snow	Participant drivers would be presented with typical information-acquisition tasks to perform using a dissemination method. Task completion time, diversions, and errors would be recorded. Feedback about information needs and technology specific comments would be solicited at the end (after participants were familiar with the technology).	Specific design information for a small set of weather events and dissemination methods (e.g., information layout and format). Some information about message content, desirable features/ information, and general information needs for the method(s) investigated.
Survey/ Interviews[2]	40-60 drivers that live in areas that flooded	1-2 different methods	Flooding, Snow	Method would use target traveler population with elements of a contextual message presentation to obtain feedback on road weather messages. Trained interviewer would present message examples (e.g., DMS) and obtain qualitative comments and subjective ratings about information needs and more specific evaluations of the messages. Drivers would be recruited at a mall or other stop-over location in flood-prone areas.	Specific design information for a limited set of messages covering a small set of dissemination methods (e.g., information layout and format). It may be possible to add in a few additional weather events if time permits.

[2] An interview format was selected over a paper-survey approach (which could reach a larger participant base) because there would likely be significant inaccuracies and inconsistencies in participant understanding of these scenarios/messages/etc. using only written descriptions.

Specify Relevant Criteria for Evaluating the Candidate Approaches

In order to systematically compare the candidate methodological approaches identified in the previous activity, a set of descriptive criteria were developed. These are shown in Table 22 below. Note that cost is not included as a decision criterion because each candidate study was developed with the same cost assumptions.

Table 22. Evaluation criteria and their corresponding definitions.

Criterion	Description	Categories
Time Requirements	Expected study implementation time. Key constraints include message or tool development and IRB approval, etc.	Expected duration in months.
Reliability of Information	The degree of confidence that the information obtained will be generalizable to relevant end-use population.	**Low** - Qualitative or descriptive information. **Medium** - Established and reliable information extrapolated from other domains, or quantitative data for which the representativeness of the sample may be uncertain. **High** - Quantitative data obtained from a representative sample of relevant end users.
Scope of Information	Degree to which the approach can provide information that applies to multiple dissemination methods and weather events.	**High** - Provides broad, high-level information applicable to a range of dissemination methods and weather events. **Medium** - General design principles that can be applied to a small set of dissemination methods and weather events. **Low** - Specific content, messages, or displays related to specific dissemination methods and weather event combinations.
Applicability	The extent to which the information obtained by a method can be directly applied to guideline development activities.	**High** - The information can be incorporated directly into Chapter 5 guideline development. **Medium** - The information requires some extrapolation to be suitable for Chapter 5 guideline development, but is likely to be "good enough." **Low** - The information is "placeholder" data that is better than nothing but should ideally be replaced by more directly relevant data.
Key Advantages	The primary benefits afforded by an approach.	E.g., easy to implement, results are generalizable across populations, etc.
Key Limitations	Key drawbacks of an approach and/or special methodological issues that may challenge the successful implementation of the research.	E.g., difficulty in obtaining appropriate participants, issues with time of year, validity of measures, unavailability of analytical sources, lower quality of message examples, etc.

Compare each Approach using a Trade-off Table

Each of the candidate methodological approaches was independently evaluated by two (2) expert reviewers using the criteria in Table 22. A consensus process was used to develop the final evaluation information. The results are presented in Table 23 below. The information in this table was used to select a recommended approach, which is discussed in the Recommendations section which follows.

Table 23. Trade-off evaluation of candidate methodological approaches.

Study Type	Time Requirements	Reliability of Information	Scope	Applicability	Key Advantages	Key limitations
Analytical Study	**3-4 months** • Some time required for document acquisition.	**Medium** • Relies on researchers to maintain reliability via selection of data sources.	**High** • Can address issues that pertain to many weather events and dissemination methods.	**High** • Should provide significant info that will fill in mid-high level guidance needs.	• Easy to implement. • Minimal technical hurdles. • Provides broadly applicable information.	• Most of the information provided by this approach will be indirect and its application to road weather messages will rely heavily on expert judgment. • The scope of the information may be limited by the available research information.
Focus Groups	**4-5 months** • Additional time for IRB approval.	**Low** • Each focus group represents a single data point. • Data are qualitative.	**Med** • Likely to address variations on a single weather event or dissemination method.	**Low-Medium** • Should provide range of information for select combinations*, but representativeness is questionable.	• Can address information needs in detail. • Can provide highly specific feedback about particular messages or their design.	• This approach provides a good starting point for message development or improvement, but some type of empirical validation of the findings will still be required. • It may be difficult to obtain an appropriate driver sample. • Quality and validity of the feedback will depend greatly on how scenarios/ messages are presented.
Laboratory Study	**4-5 months** • Additional time for IRB approval.	**Medium-High** • Recruited participants can be screened as needed.	**Low-Medium** • Likely to address limited variations on a single weather event or dissemination method. • Implementation issues limit combinations examined.	**High** • Should provide concrete design information that is directly applicable to the associated set of combinations.	• Can produce valid and detailed design information for a limited set of dissemination methods or weather events. • Performance data are relatively objective.	• The information obtained with this method will be highly specific and contribute only in a small way to completing Chapter 5 guideline development. • Creating "dynamic" mock-ups may not be possible, which will reduce the validity of the performance measures.

* The term "combination" is used to refer to a specific dissemination method and weather event combination.

Study Type	Time Requirements	Reliability of Information	Scope	Applicability	Key Advantages	Key limitations
Survey/ Interviews	**4-6 months** • Additional time for IRB approval and data collection will likely take longer.	**Medium** • Participant sample may not be representative. • Accurate representation of messages is critical.	**Low-Medium** • Likely address limited variations on a single weather event or dissemination method. • Implementation issues limit combinations examined.	**High** • Should provide design information that is directly applicable to the associated set of combinations.	• Potential to obtain direct feedback and evaluation of specific messages from a relatively large sample. • Message examples can be realistically presented and situational aspects described in detail. • Ability to draw from a larger sample will increase reliability of higher-level information needs data.	• Adequately describing the scenarios and messages may be challenging in the brief amount of available time. • Time constraints associated with interviews will limit the number of messages/scenarios that can be addressed. • It may be too expensive to collect a large enough sample of participants.

* The term “combination” is used to refer to a specific dissemination method and weather event combination.

Recommendations

Based on the trade-off analysis and other considerations, we recommended that two different types of activities be conducted for the data collection/analysis task. The first recommended approach was to conduct analytical work that could address key information gaps related to the development of road weather message design recommendations. The second recommended approach was to conduct limited data collection using a brief traveler questionnaire to obtain some initial information related to traveler use of dissemination methods and weather information in general.

Analytical Activity

One of the primary reasons for selecting this approach is the small amount of road weather message design information that is currently available relative to the very large "problem space" covered by the various combinations of weather events and dissemination methods. More specifically, an analytical activity that broadly covers a large portion of the design "problem space" was determined to provide significantly better support for the development of message design recommendations than many empirical approaches, which provide more directly applicable information, but only cover a small region of the information "problem space." This was important because incorporating more design information overall into the design guidelines was a key requirement for making them more useful to end-users. Information availability was expected to be a key challenge in during guideline development, and obtaining the most information as possible in the data collecting/analysis activity allowed us to make the guidelines as comprehensive as possible.

There is a significant amount of basic human factors design information already in existence that can be applied to guideline development. In addition, earlier activities provided several useful constraints to help focus guideline development in a way that made the analytical activities relatively efficient. For example, the scenarios described in Chapter 2 provided important information about likely travel decisions and information access points for different weather events and dissemination methods. We also identified a list of human factors and road weather information needs questions Chapter 3 (see Table 18). These sources helped identify which aspects of driver information needs were likely to be the most useful and how information from the broader human factors domain could best be applied.

Based on this recommendation, the analytical work was conducted and the key outputs of this effort were incorporated in the Chapter 5 guidelines and design tool. In addition, tutorials and other guidelines that address traveler information needs were developed. The methods information for this activity is presented in Chapter 5.

Traveler Questionnaire

The second recommended approach was to conduct limited data collection using a brief traveler questionnaire to obtain some initial information related to traveler use of dissemination methods and weather information in general. This approach carried somewhat greater technical risk, however, it was also expected to provide a greater amount of directly applicable empirical information.

A brief questionnaire was selected because it could be conducted relatively quickly and inexpensively relative to other approaches, such as focus groups and telephone surveys. This was important because the resources available to complete this work were being shared with the analytical activities described above.

A key advantage of using a questionnaire was that it could provide information that could cover some of the information gaps that cannot be addressed using analytical approaches. These include questions about the travel decisions that drivers make, and how they seek out the information they need to make those decision in the context of road weather events. Although, the short questionnaire used in this activity was limited in terms of its generalizability across weather events and geographic locations, it still provides a starting point for addressing information gaps, and provides at least initial direction on issues for which we would otherwise no data.

Questionnaire Results

The results from the brief questionnaire are provided below. The specific findings for each survey question are presented in charts showing the frequency of each response option across all respondents providing a response. Note that the order of categories in each chart mirrors the order of response options in the questionnaire.

Question 1: Which age category do you fit in?

Ninety-two (92) travelers provided responses to Question 1. Most of the travelers (30.4%) were in the 41-55 year old age category. The dispersion of the other responses was relatively balanced around this majority. The distribution of responses obtained for Question 1 is shown in Figure 12.

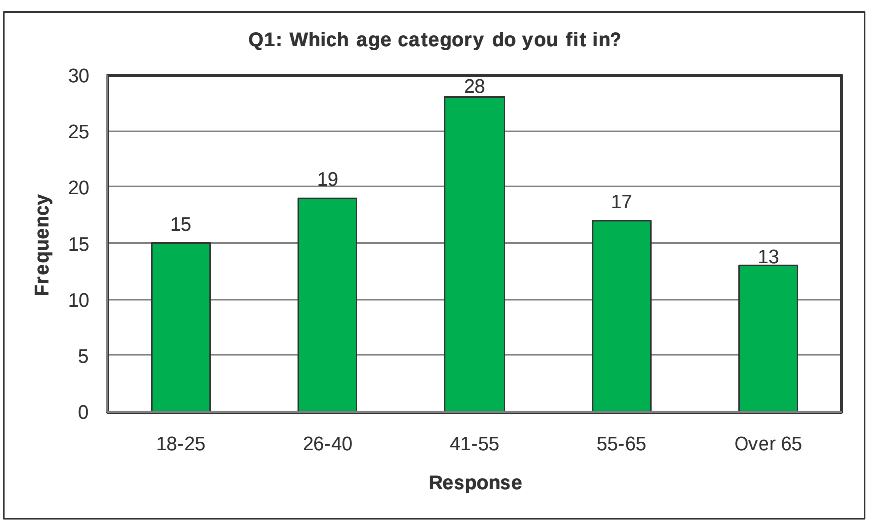


Figure 12. Responses to Question 1.

Question 2: Are you a male or female?

Ninety-one (91) travelers provided responses to Question 2. The numbers of male and female respondents were roughly equal. The distribution of responses obtained for Question 2 is shown in Figure 13.

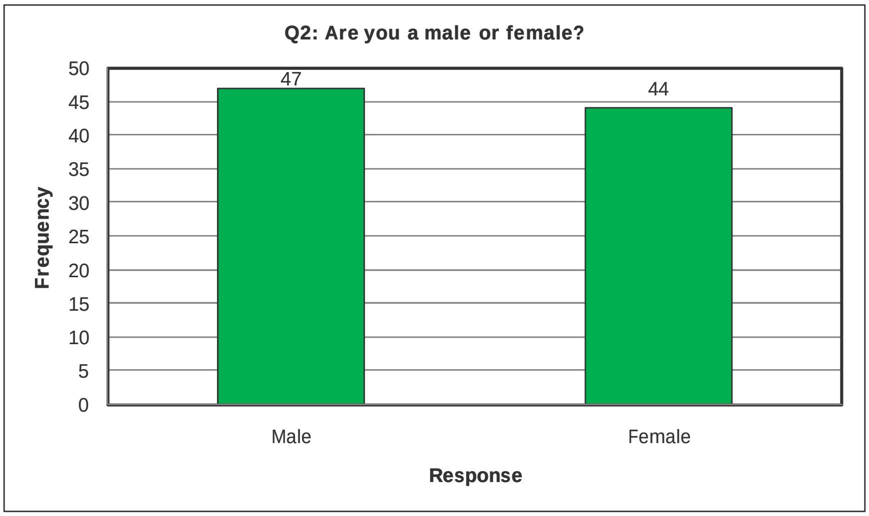


Figure 13. Responses to Question 2.

Question 3: What is the purpose of the trip you are currently taking?

Ninety-two (92) travelers provided ninety-three (93) responses to Question 3. One traveler provided two responses to the question. The main purpose of the trips was recreational (47%), followed by personal/family (27%) and work-related travel (22%). Very few commuters were observed (2%). The distribution of responses obtained for Question 3 is shown in Figure 14.

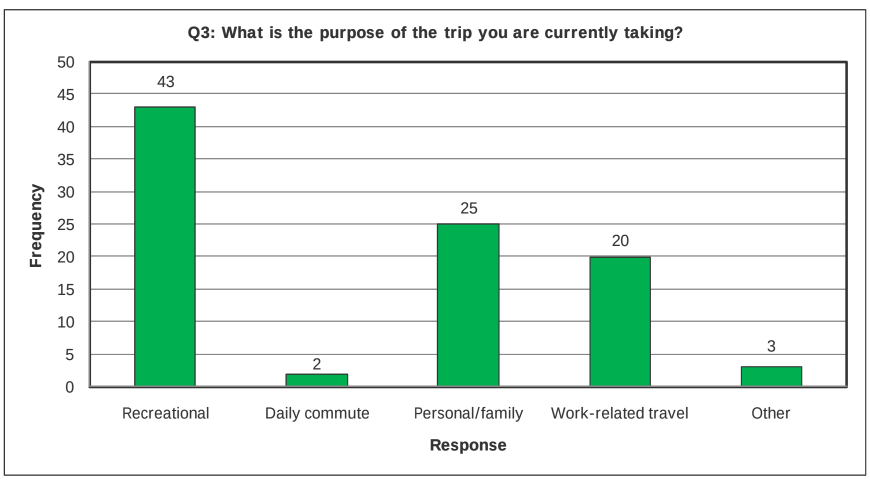


Figure 14. Responses to Question 3.

Question 4: How long do you expect your current trip to take from start to finish?

Ninety-two (92) travelers responded to Question 4. The most common response was multiple days (37%), while only 14% of travelers were traveling more than 8 hours on their current trip. The distribution of responses obtained for Question 4 is shown in Figure 15.

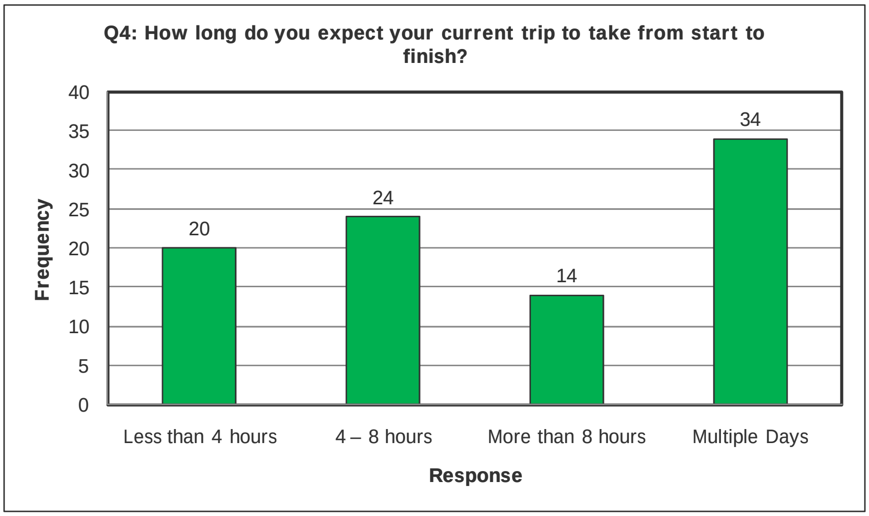


Figure 15. Responses to Question 4.

Question 5: For most of your current trip are you: driving alone, the driver with one or more passengers, or a passenger?

Ninety-two (92) travelers responded to Question 5. Most travelers indicated that they were the driver with one or more passengers (53%). The distribution of responses obtained for Question 5 is shown in Figure 16.

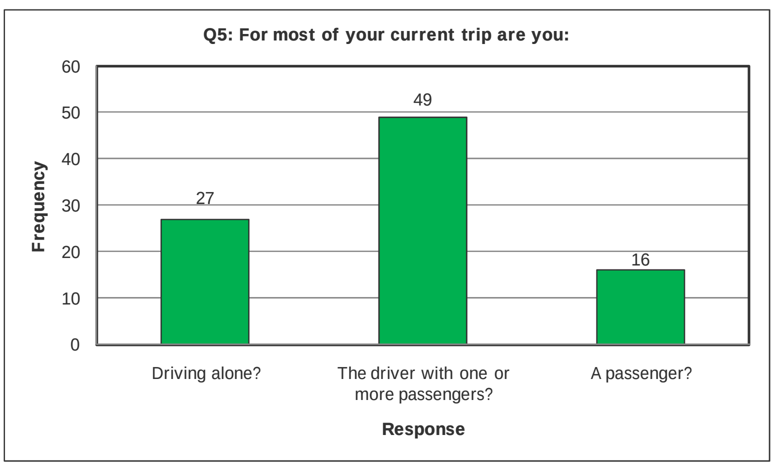


Figure 16. Responses to Question 5.

Question 6: How often, if ever, do you seek out road condition information under moderate weather events (e.g., rain, fog, etc)?

Ninety-two (92) travelers responded to Question 6. Most travelers (32%) indicated that they occasionally sought out road condition information under moderate weather conditions. The other responses were fairly evenly distributed around this central response. The distribution of responses obtained for Question 6 is shown in Figure 17.

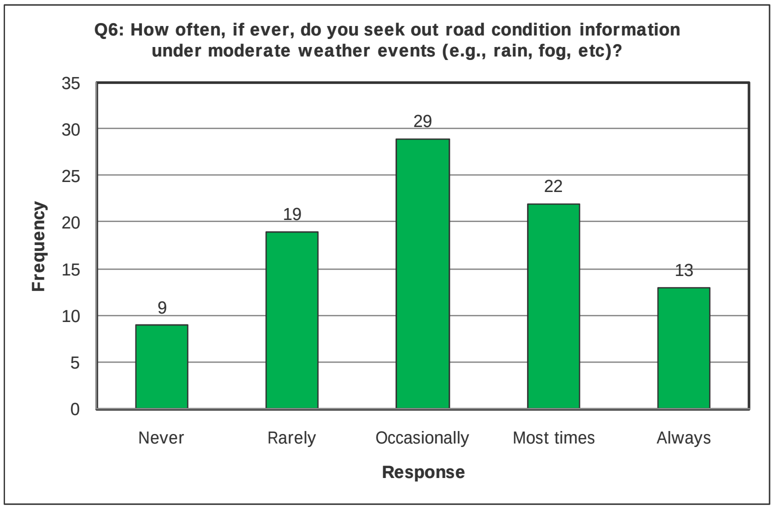


Figure 17. Responses to Question 6.

Question 7: How often, if ever, do you seek out road condition information under more severe weather events (e.g., snow on the ground, heavy rains, wind storms, etc)?

Eighty-nine (89) travelers responded to Question 7. Most travelers either always (39%) or most times (35%) seek out road condition information under more severe weather events. The distribution of responses obtained for Question 7 is shown in Figure 18.

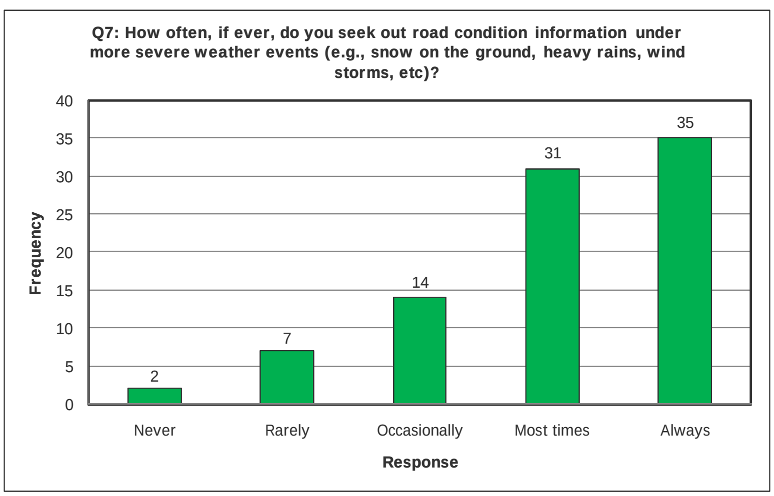


Figure 18. Responses to Question 7.

Question 8: In the past year, have you encountered a weather event in which you were concerned about the condition of the roads that you or someone in your household might encounter while driving?

Ninety-two (92) travelers responded to Question 8. The majority of travelers (78%) responded "yes" and proceeded to answer Questions 9 through 13. Those travelers that responded "no" skipped directly to Question 14. The distribution of responses obtained for Question 8 is shown in Figure 19.

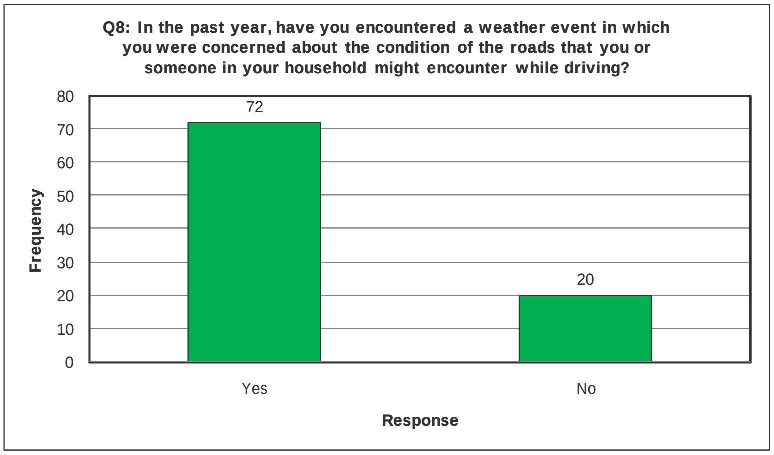


Figure 19. Responses to Question 8.

Question 9: What was the weather event?

Seventy-two (72) travelers provided one hundred thirty-five (135) responses to Question 9. Multiple responses could be provided as the weather event of concern from Question 8. Most travelers (83%) were concerned about snow, with the second most common response being icy roads (54%). The distribution of responses obtained for Question 9 is shown in Figure 20. Note that the Seattle area had an unusually high amount of snowfall in the 2008-2009 winter, in addition to separate events involving flooding of rivers in low-lying areas.

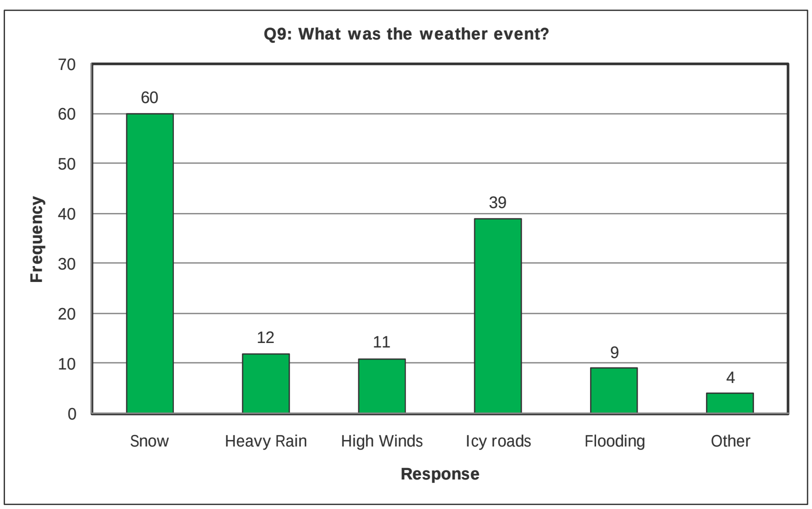


Figure 20. Responses to Question 9.

Question 10: What specific road conditions were you concerned about?

Seventy-two (72) travelers provided one hundred fifty-nine (159) responses to Question 10. Multiple responses could be provided as the road conditions from the weather events indicated in Question 9. Most travelers (69%) were concerned about slippery conditions, with the second most common response being road closures (61%). The distribution of responses obtained for Question 10 is shown in Figure 21.

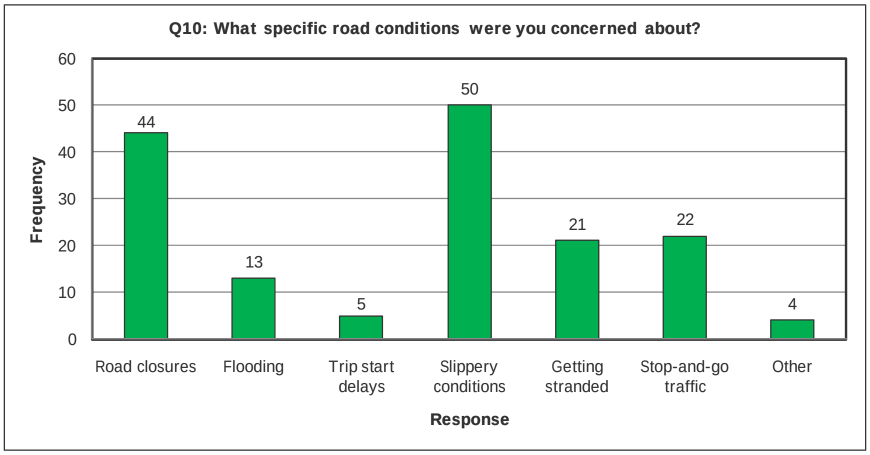


Figure 21. Responses to Question 10.

Question 11: What was your primary source of information about road weather conditions?

Seventy-two (72) travelers provided one hundred three (103) responses to Question 11. The question indicated that one primary source of information should be specified, however twenty-three (23) travelers gave multiple responses, and so all responses were included. The majority of travelers responded that they used TV or radio forecasts (42%) and/or state Department of Transportation (DOT) or other road weather information websites (39%) as a source of information. The distribution of responses obtained for Question 11 is shown in Figure 22.

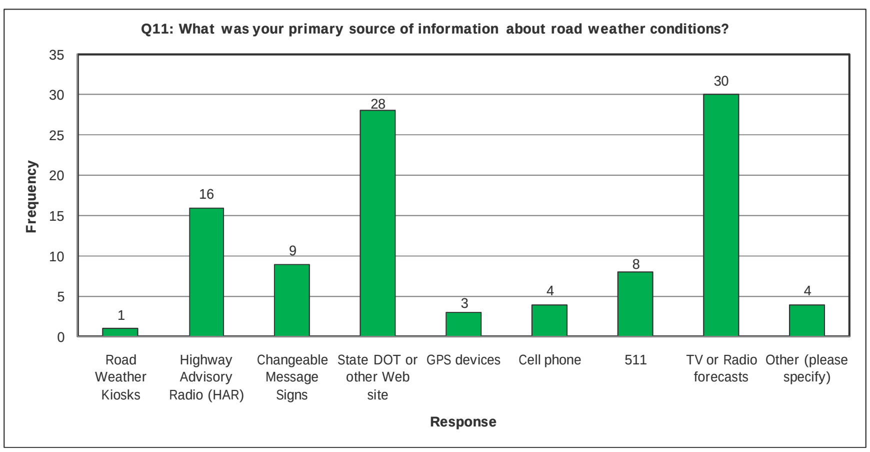


Figure 22. Responses to Question 11.

Question 12: How reliable was the information you obtained?

Seventy-two (72) travelers provided responses to Question 12. Most travelers (58%) indicated that the information that they received was either very or mostly reliable (18% said very reliable and 41% said mostly reliable), while 28% of travelers found the information to be often reliable. Only one respondent reported that the information they obtained was not reliable at all. The distribution of responses obtained for Question 12 is shown in Figure 23.

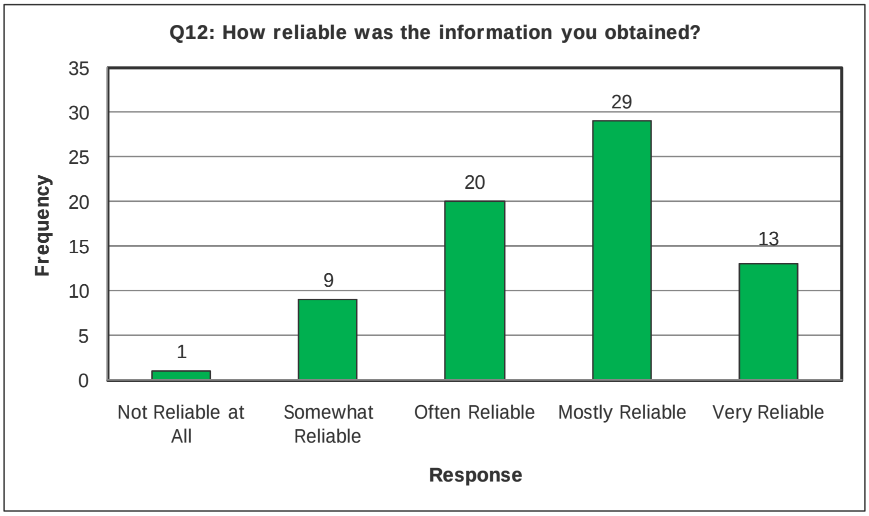


Figure 23. Responses to Question 12.

Question 13: Did you make any of the following changes to your travel plans based on the information you obtained?

Seventy-two (72) travelers provided one hundred forty-five (145) responses to Question 13. Multiple responses could be given because multiple changes to travel plans could be made. The most common responses were driving with extra caution (50%), leaving earlier (42%), and taking a different route (36%). The responses were fairly spread among the categories with few travelers (11%) not changing their plans at all. The distribution of responses obtained for Question 13 is shown in Figure 24.

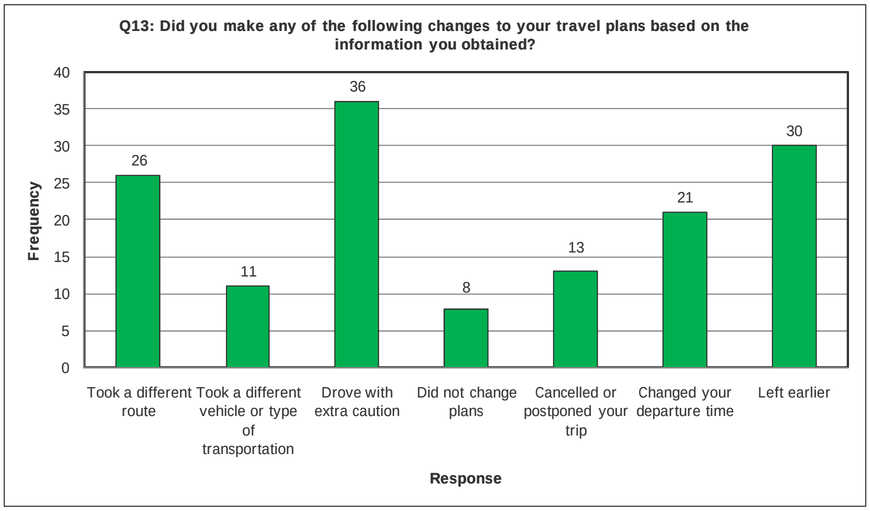


Figure 24. Responses to Question 13.

Question 14: How important do you think the following types of road-weather information are?

Ninety-one (91) travelers provided responses to all or some parts of Question 14. Overall, travelers thought that the road-weather information types listed were very important or somewhat important (96% on average). The main distinction was that information indicating that there are weather-related travel delays or slow-downs on the roads was deemed less important (51% very important) compared to the other information categories (79% average very important). The distribution of responses obtained for Question 14 is shown in Figure 25.

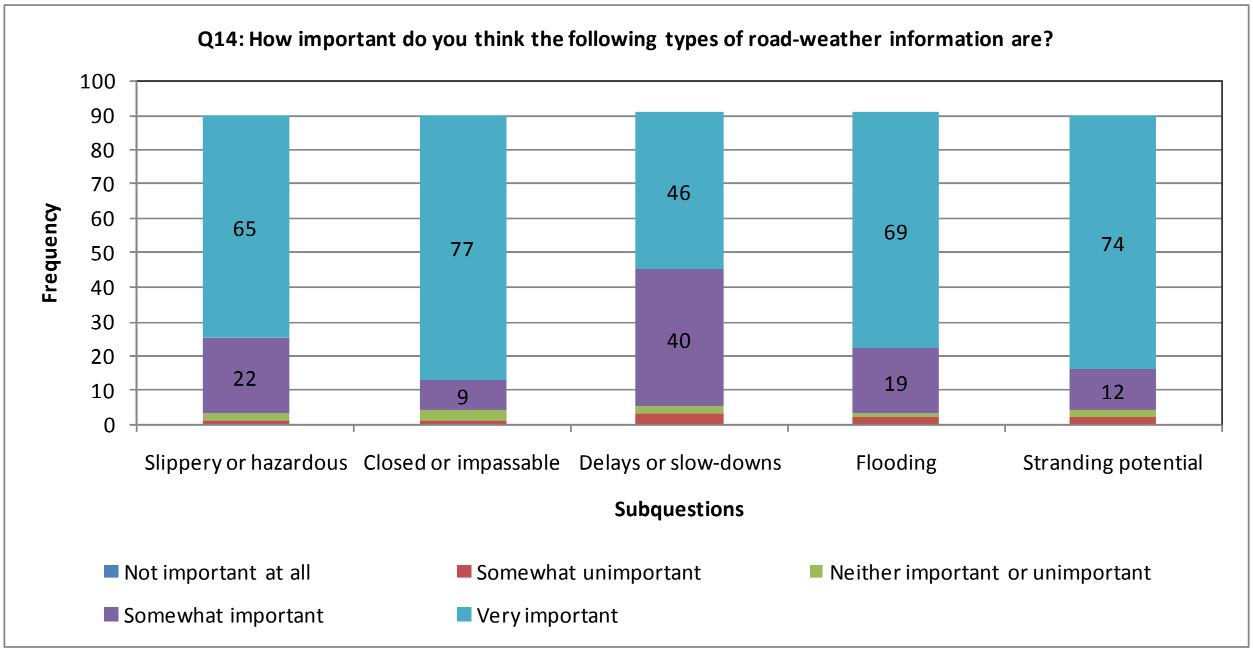


Figure 25. Responses to Question 14.

Question 15: How useful do you think it is to obtain road condition information at the following points prior or during your trip?

Ninety-two (92) travelers provided responses to all or parts of Question 15. Travelers thought road condition information was most useful prior to leaving, within one hour of their departure time (80% very or mostly useful). The distribution of responses obtained for Question 15 is shown in Figure 26.

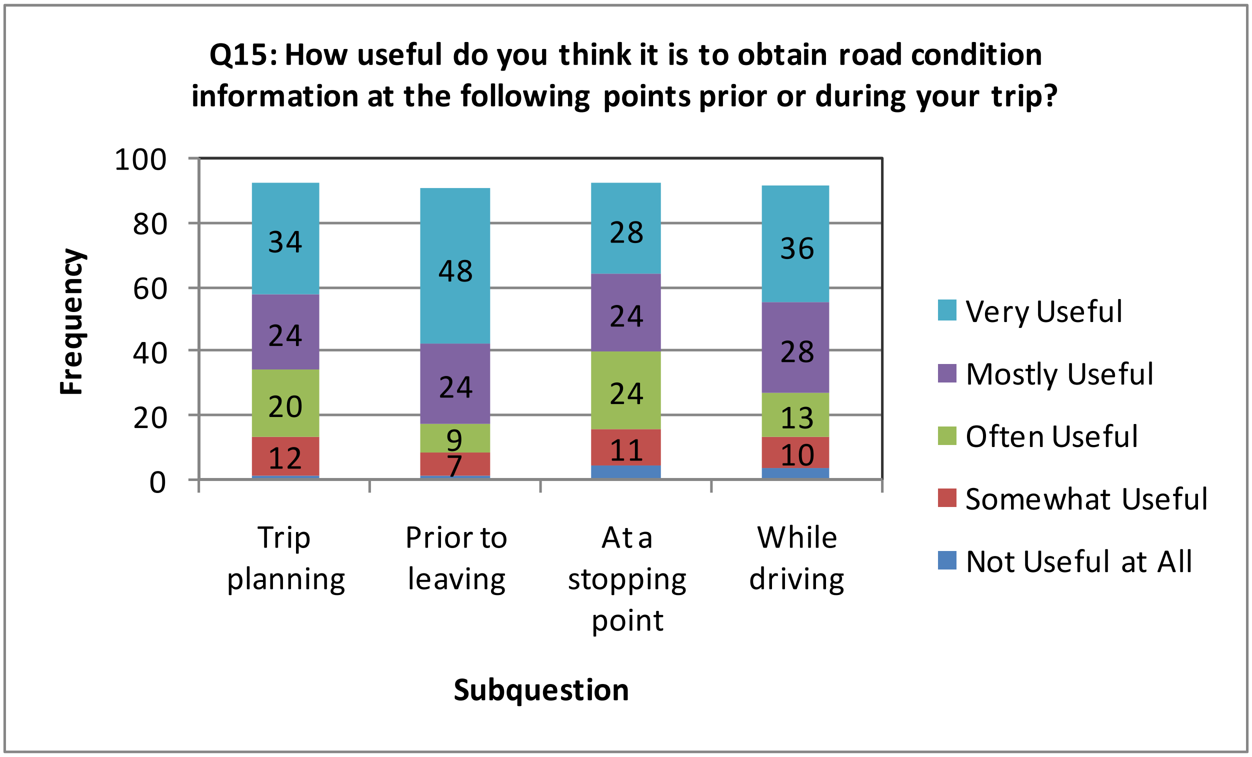
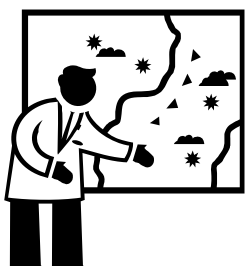
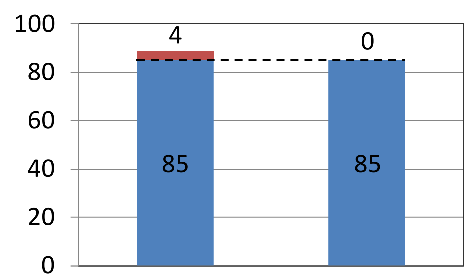
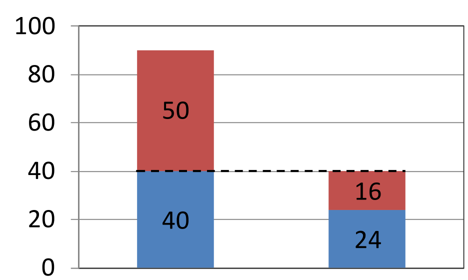
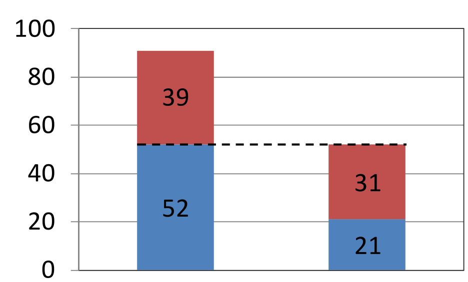


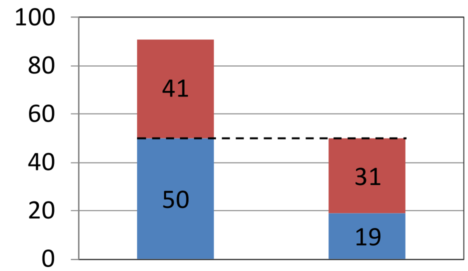
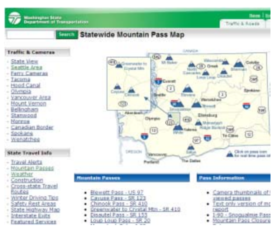
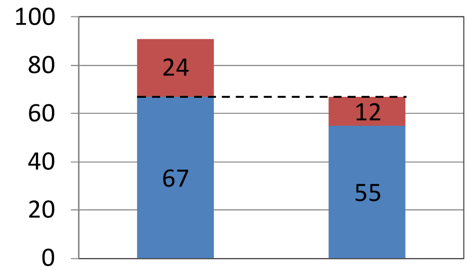
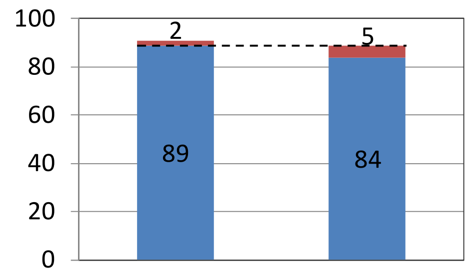
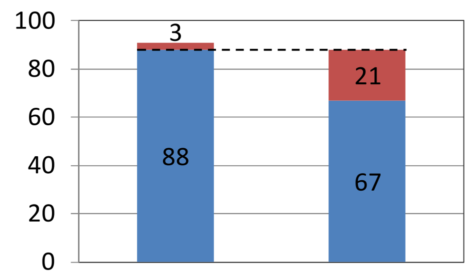
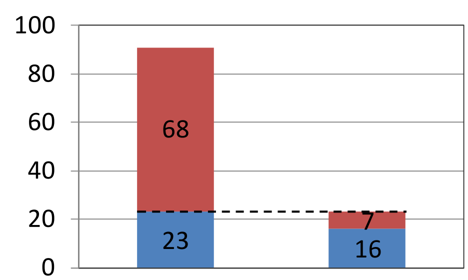
Figure 26. Responses to Question 15.

Question 16: The following boxes describe sources of road weather information Please tell if you are aware of these sources for road condition information and if you have ever used them before.

Ninety-one (91) travelers provided responses to all or parts of Question 16. The most commonly used sources of weather information for travelers are regular TV or Radio weather forecasts (94%) and DMS (93%). The least commonly used sources of weather information are Road Weather Information Kiosks (18%), Global Positioning System (GPS) navigation devices (21%), and cell phone road-weather applications (24%). The distributions of responses obtained for Question 16 are shown in Table 24.

Table 24. Responses to Question 16.

<table>
<tr><th>Picture</th><th>Road-weather information Source</th><th>Responses
(Upper Blue Section: Yes, Lower Red Section: No
Left column: aware of source
Right column: used source)</th></tr>
<tr><td>
Note: This figure is not the original graphic used in the survey. The original was a picture of a local news-weather forecaster presenting traffic congestion information on a city map.</td><td>Regular TV or Radio Weather Forecasts</td><td>
</td></tr>
<tr><td></td><td>511 Telephone Information Services</td><td>
</td></tr>
<tr><td></td><td>Cell Phone Road Weather Applications</td><td>
</td></tr>
</table>

<table>
<tr><th>Picture</th><th>Road-weather information Source</th><th>Responses
(Upper Blue Section: Yes, Lower Red Section: No
Left column: aware of source
Right column: used source)</th></tr>
<tr><td></td><td>GPS Navigation Devices</td><td></td></tr>
<tr><td></td><td>State DOT or other Road Weather Information Website</td><td></td></tr>
<tr><td></td><td>Changeable Message Signs by the Roadside</td><td></td></tr>
<tr><td></td><td>Highway Advisory Radio (HAR)</td><td></td></tr>
<tr><td></td><td>Road Weather Information Kiosks</td><td></td></tr>
</table>

Summary of Empirical Results

Although it would have been preferable to collect data from a larger number travelers overall, the participants seem generally representative of travelers in Washington State and, importantly those that are disposed to seek out and make use of weather information provided by a range of sources.

In general, we obtained responses from travelers representing a reasonable range of demographic characteristics. Moreover, the timing of data collection enabled us to capture information related to severe weather events that happened in the Seattle region within the last year. By asking questions that focused on travelers' actions during these events, we were able to obtain information that may more reliably reflect actual behavior, rather than if we had asked about hypothetical actions during a candidate weather event. The results also showed a range of traveler responses in terms of when and where they obtained their information, and how they changed their travel plans. It is certainly clear based on the results to Question 13 that travelers will use weather information to adjust their travel plans.

Another key finding is that, although television and radio broadcasts about weather are frequently used by travelers, other key sources include DMSs, DOT websites, and HAR, which are directly controlled by state DOT operators and staff.

We were also able to use the results from several of the questions to help answer some of the human factors questions addressed as part of the analytical activities described in Chapter 5. The information used from this survey included:

- Questions #11 & 16: Sources and past use of various dissemination methods for weather information
- Question #13: Changes to travel plans based on weather information received
- Questions #14: Relative importance of information about weather-related driving impacts, and
- Questions #15: Usefulness of weather as a function of when the information is received

CHAPTER 5: PRELIMINARY GUIDELINES FOR DISSEMINATING ROAD WEATHER INFORMATION

The objective of this phase of the project was to identify improvements that can be made to existing weather messages and dissemination strategies, and to recommend relevant guidelines for communicating weather information to travelers.

In this activity, we used the results described in earlier chapters as a basis for identify additional analytical research that can be conducted to address gaps in needed information, and in the development of the guideline and other supporting information, such as tutorials. The primary objective of this activity, however, focused on developing a series of guidelines for road weather message design characteristics, and on organizing these in terms of a range of dissemination methods. A part of this included the development of a road weather message design tool, which represents an optional, structured process that message designers can walk through to obtain guidance on how to better integrate information about traveler information needs into road weather messages.

Two primary activities are described in this chapter. The first involves the analytical activity recommended as part of the tradeoff analysis described in Chapter 4. The reason for including discussion of this activity in the current chapter is that the results of this analytical activity were directly applied to development of the guideline and message design tool. Consequently, while the methodological approach for the analytical activity is discussed separately below, the corresponding results are not covered separately from the results from the guideline development activity.

The second primary activity is the development of the road weather message design tool and separate design guidelines. This was the key outcome of the current project, and all of the activities described up to this point were conducted in support of this work. The design tool was developed to help message designers better incorporate traveler information needs and other human factors considerations into their message design process. The design tool follows a structured, 4-step process (with optional steps) that guides designers through the process of identifying relevant road weather conditions, corresponding travel decisions, and available suitable dissemination methods, and then provides information about which design guidelines or tutorials provide applicable design information.

In conjunction with the design tool, a total of 30 guidelines were developed covering content and wording of messages, message presentation and layout, and other general issues, such as communicating information about urgency or uncertainty. In most cases, different design recommendations were provided for different types of dissemination methods. More specifically, the guidelines focused on three different types of dissemination methods, including:

- **Short text/visual messages:** Brief text-only messages that have space/character-number restrictions (e.g., DMS, cellular text-messaging, Twitter, etc).
- **Open format text/visual messages:** Visual message formats that are not inherently restricted in terms of length and can include of graphical elements, such as maps, icons, or video (e.g., web-pages & information kiosks).

- **Auditory messages:** Spoken word messages involving pre-recorded or synthesized voice messages, with no visual elements (e.g., 511 or HAR).

Methods

Key technical activities included:

- Analytical Activities to Address Key Human Factors Questions and Traveler Information Needs
- Develop Recommendations and Standards

Each of these activities is described in more detail below.

Analytical Activities

The objective of the analytical activity was to try to answer as many of the human factors questions identified in Table 18 as possible. Two primary approaches were used to meet this objective. The first was to identify and summarize information from existing research, including 1) research sources identified in earlier project tasks that address weather messages, and 2) human factors research sources from other related areas, such as traveler information systems and basic human factors research. The second approach involved using qualitative analyses and expert judgment to derive key information when insufficient empirical data were available to provide a more direct answer. These two approaches are described in more detail below.

Literature Synthesis

A literature synthesis approach was used to summarize available research information related to the human factors questions in Table 18. The basic method involved using a structured format to capture key findings from relevant research sources. The specific approach was similar to one we have used in the past for developing annotated outlines for NCHRP’s Human Factors Guidelines for Road Systems (Campbell, Richard, & Graham, 2008). However, the format we used in this activity was less formal because a more rigorous format requires significant overhead to implement for each research source, and we determined that this was unnecessarily inefficient since most reports contain only a few relevant findings. An example of the structured format used to summarize findings is shown in Table 25. The key elements include:

- **Approach:** A one-sentence summary of the general research approach.
- **Caveats:** Description of any methodological issues that potentially compromise the generalizability or validity of the reported findings.
- **Findings:** A bulleted list of information or findings that is suitably detailed to incorporate into the decision-tool framework.

The final document summaries are provided in Appendix D. Note that the findings from some reports were presented under more than one question if the report contained information relevant to both (the findings details were not duplicated). As part of the current analytical activity, we also used information directly from the document review conducted as part of the Chapter 3 in this report, although we did not include this information in the synthesis table.

Table 25. Example summary table and fields used in the literature synthesis.

1. **Human Factors Question.**	
Brief summary of approach or type of research report *Caveats:* - Caveat 1 - Caveat 2 *Findings:* - Finding 1 - Finding 2	Document Reference Information

Qualitative Analyses

These represent a general approach used to organize information elements in a logical way (typically using tables) to provide information about the questions being addressed. This process involved using available information and constraints along with expert judgment, clearly defined categories, and specific assumptions to logically infer or deduce relationships among key information elements. Qualitative analyses were conducted as part of the human factors questions addressing:

- When drivers can make the best use of road weather information (Question 4).
- What types of weather conditions require road weather information to preserve safety (Question 6).
- What factors determine which dissemination methods drivers will use to obtain road weather information (Question 13).
- How can the safety impacts of a driver obtaining road weather information while on the road be minimized.

The outputs from these qualitative analyses were included in several of the tutorials in Appendix E. More specific details about the assumptions and caveats associated with each question can be found there.

Development of the Road Weather Information Design Tool and Design Guidelines

The recommendations and guidelines were developed through a combination of *integrative review* and *analytical activities*. In general, the *integrative reviews* summarized previous research or existing information by aggregating the results of a number of similar data sources. With respect to a specific guideline topic, this means that the results, recommendations, or guidelines from reviewed data sources described previous chapters—as well as the Chapter 4 data collection activity—were qualitatively compared, contrasted, and perhaps combined. The criteria that were used to evaluate individual data sources included: usefulness, clarity/understandability, timeliness, accuracy, and specificity as they relate to traveler information requirements for road weather messages.

The term "*analytical activities*" is used here to describe the general task of reducing all inputs from the previous chapters to intelligible and interpretable form. These activities included categorizing, ordering, manipulating, and summarizing the sources reviewed and the available data on how to improve current practices to improve road weather information provided to drivers. As appropriate, the recommended improvements, standards, guidelines, etc. produced in the current chapter were supplemented with constraints, trade-offs, caveats, exceptions, and special human performance issues.

In past guideline-development projects, we have found that using a concise, consistent, highly-structured presentation format leads to the highest levels of understandability and acceptance by end-users[3], and is most likely to be implemented in real-world systems. Accordingly, the guidelines in the current chapter have a consistent "look and feel," but—unlike our previous guideline efforts—are not always constrained to a rigid 2-page format; some are provided in a single page, while others are longer than 2 pages.

Several "tutorials" were also developed to supplement the road weather message guidance provided in this report. The purpose of these tutorials was to provide end-users with more general information relevant to what information drivers need and how they might use road weather messages. The tutorials were based primarily on information developed during the analytical activities described in the previous section, as well as past research in the areas of driver behavior and traveler information needs. The tutorials are provided in Appendix E.

The set of guideline recommendations that pertain to web-based information was develop using a different approach than the other guidelines. The reason for this is that there was almost no relevant design information from existing sources regarding the presentation of road weather information on websites (the exception was basic guidance on presenting map-based information). However, this is a key dissemination method since 50 out of the 51 states (including the District of Columbia) provide or link to weather-related information from a website. In the absence of pre-existing guidelines, we conducted a review of the 51 state (including the District of Columbia) websites to look for common or best practices in the presentation of weather information. Additionally, the top eight commercial weather websites (according to alexa.com) and the National Weather Service (NWS) website were also reviewed to provide a broader survey of weather information. Upon examination, it was found that the content on the Yahoo Weather site is provided by Weather.com, and thus Yahoo Weather was removed from consideration.

The website review was organized around a set of basic design questions. These were developed based on a preliminary review of the features available on a small sample of state DOT websites. The specific questions examined included:

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[3] The term "end-users" is used exclusively in this report to refer to the transportation professionals that would be responsible for applying the road weather information guidance and recommendations. This term is not used to refer to travelers, who have a different set of information needs related specifically to their use of road weather information.

- What is the URL for the DOT homepage and which links on this page lead to the weather information?
- Are severe weather alerts given separately from the regular weather information and how are these alerts formatted?
- Is there general weather information provided that is updated on a daily basis (such as forecast information, or weather station data)?
- Is there a weather-related map provided that shows weather information and/or traffic congestion/traveling speeds?
- Are live camera or static images of roadways provided?
- Is a table, list, or database of weather-related information provided?
- Does the website provide a method of supporting other dissemination methods and/or link to other weather sites?

Information relevant to each question was obtained during the review of each website. Each search began at the state DOT website and all weather information on that site was catalogued. However, some states rely solely on links to 511 or other external sites to provide road condition information; from the state DOT website, these other sites were visited. The features that were used within the individual websites and more specific characteristics of these features were recorded in separate tables (see Appendix F).

Results

Analytical Activities

The outputs from the analytical results served as an intermediate step in the overall development of the design tool and guidelines. Since this information was integrated into the final guidelines, they are not described separately. Research article summaries from the literature synthesis activity are provided in Appendix D. Also, Appendix E contains design guidance and tutorials related to traveler information needs, which were developed directly from the information provided during the analytical activities.

Description of the Road Weather Message Design Tool

One of the key objectives of the current research effort was to recommend relevant standards for communicating road weather information to travelers. As described in previous chapters, a message design tool that takes into account specific traveler information needs and driving behaviors was identified as a suitable method for meeting this objective.

The rationale for this approach is straightforward: a message design tool is the most efficient way to integrate the large number of different possible combinations of weather events, safety and mobility impacts, traveler decisions and behaviors, and dissemination methods into specific recommendations for road weather messages. In particular, the “problem space” associated with these various combinations is so large that providing specific guidance for each combination would result in a product that would be unwieldy and—ultimately—of little use to state DOT staff and other end-users of the message design recommendations.

For example, a winter storm can have many different impacts on travel (e.g., road closures, reduced capacity, low traction, low visibility, etc.), and different types of travelers will be concerned about these impacts in different ways (e.g., concerns about being late, concerns about getting stranded, etc.) and they will have different options with regard to dealing with their concerns (e.g., staying home, changing route, departing earlier, etc.). This situation is further complicated by the fact that travelers have several options for obtaining information (e.g., TV/radio, DMSs, HAR, etc.), and the suitability and availability of these dissemination methods also varies based on the traveler's situation, such as trip stage, etc. Finally, the message design recommendations are themselves closely tied to the types of dissemination methods selected, because the dissemination methods differ in terms of format (e.g., short text, auditory, graphics, etc.) and how much information can be provided.

Thus, a key challenge throughout the conceptualization and planning of the message-design recommendations was how to navigate the complex relationship between all these factors in way that is not unnecessarily burdensome and confusing to the end-user, who just wants recommendations for how best to communicate road-weather messages to travelers. Based on some of our initial work, it was clear that some type of message design tool would be necessary to make navigating the large number of message design issues tractable and more efficient.

The following sections provide a detailed overview of how the message design tool works. This discussion includes the rationale for the tool, in addition to a more detailed explanation of how end-users can use it.

Rationale: When a weather event occurs, it will have some impact on the travel network that may have certain implications for travelers (we refer to these as *Safety and Mobility Impacts*). For example, heavy rains could lead to flooding on some roads, and the closure of some road segments. Travelers originally intending to use the closed roads will now have to change their plans since their original route is no longer available. Moreover, these situations become more complicated because the decisions that travelers make—and how they obtain their information—depend on a variety of factors including driver demographic factors, type of trip, the stage of their trip, etc. For example, a traveler seeking road weather information before departing has several options regarding where they seek information (e.g., home internet, TV, 511, etc.) and several options regarding their response (e.g., plan a different route, delay their departure, cancel their trip, etc.). In contrast, a traveler already on the road will be limited to a different set of available dissemination methods (e.g., DMS, HAR, 511, etc.), and travel options (e.g., take a detour, but not easily cancel or postpone travel). Finally, when travelers get around to seeking out road weather information, how the information is presented can also effect whether or not travelers can make use of it. For example, if a message is difficult to understand, read, or hear, then travelers will be less likely to use that information to make good travel decisions. In summary, an approach to providing effective road weather information to travelers should contain three key elements:

1. Information that supports the key travel decisions they need to make

2. Information that is provided to travelers using dissemination methods that are available and suitable for them to use based on their travel situation, and
3. Message content that is easily understood, and displayed in a manner that can be clearly read, heard, etc.

The message design tool provides guidance related to the above three topics for a given set of weather events and corresponding safety/mobility impacts. The design tool works in four steps plus one optional step, and is comprised of seven questions that help specify: 1) the relevant message content, 2) suitable dissemination methods, and 3) specific design recommendations for developing messages that address the weather event and safety/mobility impacts of concern. The basic steps and questions are described in Table 26 below.

Table 26. Questions associated with the key message design tool steps.

Question	Description
Step 1: Identify safety/mobility impacts based on the weather event	
What is the weather event?	Identifies key safety/mobility impacts, and provides contextual information for message content and details about the weather event in general (e.g., timeframe, location, etc.).
What are the safety/mobility impacts of greatest concern?	Used to identify the travelers' key travel decisions, which correspond to their key information needs.
Step 2: Identify likely travel decisions and suitable Dissemination Methods	
What are the key trip decisions and behavior changes that travelers would likely make in response to the safety/mobility Impacts?	Travelers will seek out information based on what travel plan changes they have to make (i.e., their travel decision). This information is related to the weather message content.
What Dissemination Methods are most suitable given the traveler's situation?	Used to identify the dissemination methods that are most likely to be suitable/available to travelers, based on their travel situation.
Optional Step 2a: Lookup relevant traveler information needs	
What are the specific traveler information needs?	Can be used to identify information that should be included in the road weather messages to support traveler decision making. This step is optional and only required if the additional guidance is needed regarding what the message should say.
Step 3: Lookup relevant design recommendations	
For the specified Dissemination Methods, which human factors design recommendations apply to the message content and presentation format?	Used as a "look-up table" to identify specific message design guidelines that are specific to the identified Dissemination Methods.
Step 4: Apply design recommendation information	
What are the specific design recommendations?	This is the key message design recommendation information. This guidance provides information about how to communicate a message that is easy to read/hear and understand given the presentation constraints inherent in specific dissemination methods.

The seven questions are structured around four separate tables that mostly follow a linear progression plus a separate chapter that will contain the actual design recommendations (see Figure 27). The first table (Step 1) helps identify the key safety/mobility impacts associated with the weather event. Once the primary safety/mobility impacts of concern have been selected, the second table (Step 2) identifies the key travel decisions and suitable dissemination methods associated with the mobility impact. If additional information is required about likely traveler information needs, then optional Step 2a provides this guidance for finding information about individual travel decisions. Finally, the last table (Step 3) provides a “roadmap” to the specific message design recommendations available for the message content and presentation based on the parameters selected in the previous tables. The specific design recommendations (Step 4) are contained in a separate chapter.

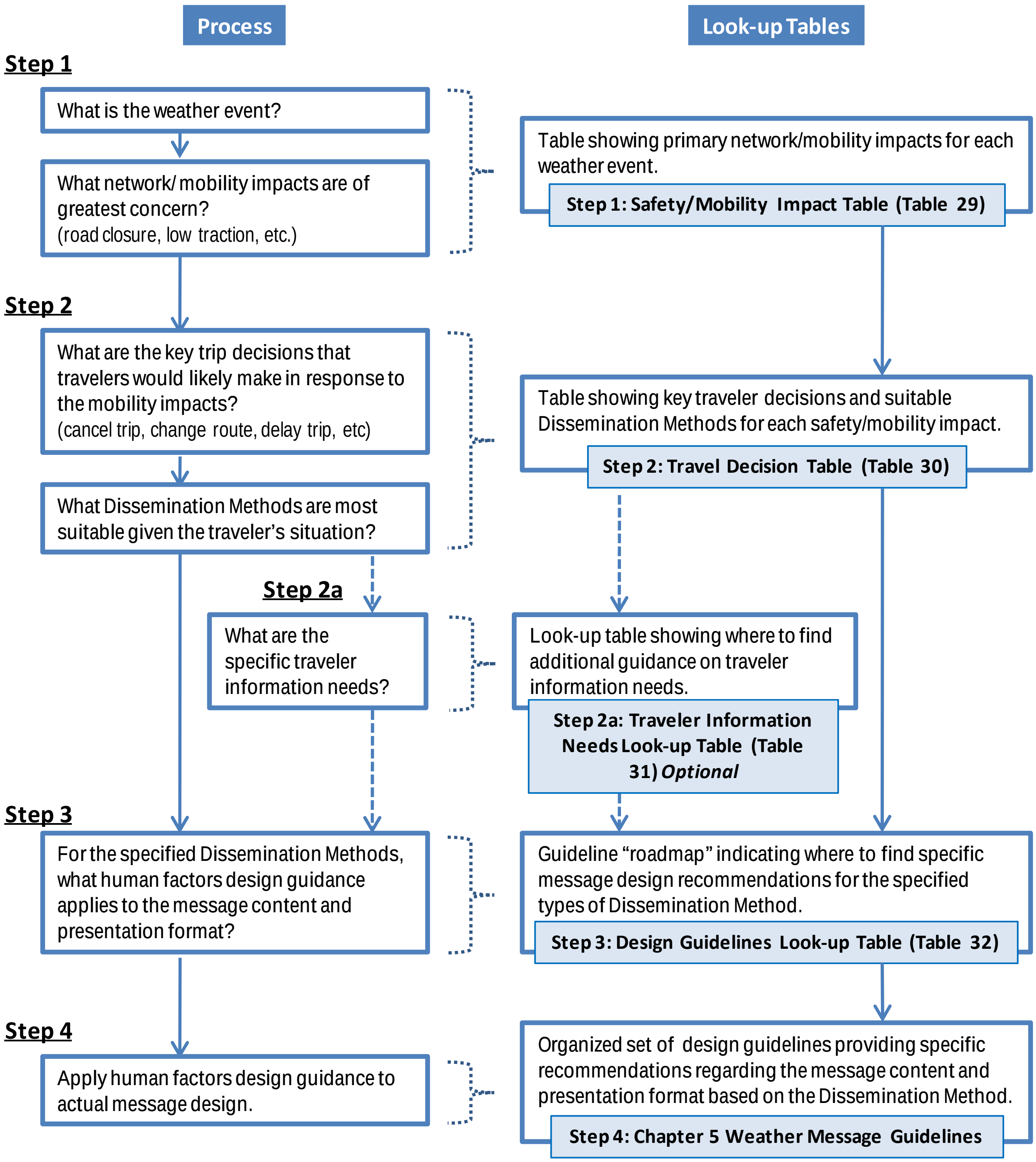


Figure 27. Message design tool steps and questions for finding design recommendations shown with their associated look-up tables.

It is not necessary to start at Step 1 in this process; the tool is designed to provide flexibility to an end-user for extracting information. In some cases, the weather impacts may already be specified or dictated by existing DOT communication policies. In these cases, end-users could begin at Step 2 if they require information about likely travel decisions and suitable dissemination methods. Alternatively, they could go right to Step 3 to find specific message design guidance from the “road-map” table, if they already know what message they must communicate and which set of dissemination methods must be used.

Each of the steps listed above, along with its corresponding rationale, is described in more detail in the following sections.

Step 1: Identify safety/mobility impacts based on the weather event

The first step of the process involves identifying the road safety/mobility impacts that are of greatest concern for the weather event in question.

Question 1: What is the weather event?

The weather event is the primary starting point in this process. It essentially provides a high-level way to organize the associated road weather concerns. For example, a single weather event could be associated with several different impacts on the road network (e.g., blowing snow, slippery roads, road closures, etc. during winter storms). In addition, certain secondary information is tied more generally to the weather event, such as its timeframe, geographic extent, the likelihood of it affecting a certain region, etc. The message design recommendations will also provide separate guidance for incorporating this secondary information in road weather messages if this information is important, and can be accommodated by a specific dissemination method.

Question 2: What are the safety/mobility impacts of greatest concern?

These impacts reflect the specific ways in which the road network or general traveler safety and mobility are affected by the weather event, such as closure of road segments, capacity reductions, etc. It is useful to specify the effects of a weather event in terms of these impacts because they determine what decisions travelers ultimately have to make with regard to their travel plans or behavior (e.g., driving more cautiously).

Likely weather event and safety/mobility impact combinations are shown in Table 29 (cells that are not shaded blue). To make this table easier to use, combinations that are unlikely to occur are shaded blue. The reason for doing this was to highlight combinations where the safety/mobility impact was a direct consequence of the weather event, rather than just being associated or indirectly linked with the event. However, it should be noted that there is no specific reason to avoid selecting a blue-shaded combination if it makes sense to do so based on conditions. Note that most weather events have multiple associated safety/mobility impacts. Tutorial 4 provides additional guidance for prioritizing these impacts based upon personal safety risks, crash risks, and convenience/schedule impacts for the traveler.

These safety/mobility impacts are primarily based on those used to develop Traffic Management strategies for addressing various weather events as defined in the FHWA ConOps report on “Weather-Responsive Traffic Management: Concept of Operations” (Cambridge Systematics, 2003). However, some weather impacts were added to cover additional traveler concerns that were not included in the original document (e.g., stranding conditions), and others were changed based on feedback from the FHWA. The full list of weather impacts used in scenario development is provided in Table 27 below:

Table 27. Definition and associated weather events for each weather impact.

Safety/Mobility Impact	Associated Conditions	Impact on Travelers
Total Road Closure	Blizzard conditions, White-out conditions, Moderate to heavy snow, Sleet or freezing rain, Flooding, Thunderstorms, High winds	Requires detour onto alternate routes or delaying travel.
Reduced traction	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain	Drivers should be more cautious in the affected area.
Low visibility	Blizzard conditions, White-out conditions, Blowing snow, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Smoke/mist/fog	Drivers should be more cautious in the affected area.
Lane Obstruction/ Reduced capacity	Blizzard conditions, White-out conditions, Blowing snow, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Drizzle or light rain, Flooding, Thunderstorms, High winds, Smoke/mist/fog	Likely to cause moderate to high levels of traffic congestion in the immediate area. Debris on roadway, lanes unavailable because of snow obstruction/clearing or partial flooding. Also, vehicles pulling over to side of the road, washed out roadways or pavement damage.
Congestion/ Reduced speed	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Flooding, Smoke/mist/fog	Greater speed variability in traffic and loss of roadway capacity.
Traffic Control Device (TCD) Malfunction	Blizzard conditions, White-out conditions, Moderate to heavy snow, Sleet or freezing rain, Thunderstorms, High winds	Traffic signals are non-operational leading to increased congestion.
Unsteady Driving/ High Winds	High winds	Drivers (particularly those of larger vehicles/trucks, RVs) should be more cautious in the affected areas.
Flooding/ Water Ponding	Moderate to heavy rain, Flooding, Thunderstorms	Drivers are at risk of being stuck or stranded mid-travel. Potential road closures. Drivers should be more cautious in the immediate area.
Maintenance Vehicles on Road	Blizzard conditions, Blowing snow, Bridge or road frost, Extreme cold, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Flooding, Extreme heat	Drivers should be more cautious in the affected area. Maintenance vehicles on the road may reduce roadway capacity, leading to increased congestion.
Transit, Bus Delays/ Stoppage	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Extreme cold, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Flooding, Thunderstorms, High winds, Smoke/mist/fog	Travel by transit has a higher time cost.
Sun Glare	Extreme heat, Fair weather	Drivers should be more cautious in the affected area.
Extreme Temperatures	Extreme cold, Extreme heat	Drivers should prepare for conditions by bringing along appropriate gear/supplies.

Step 2: Identify likely travel decisions and suitable dissemination methods

Based on the key safety/mobility impact identified, the next step is to identify the key decision that travelers would likely want to make based on the weather impacts. In addition, it is also necessary to identify suitable dissemination methods based on these situational factors.

Question 3: What are the key trip decisions and behavior changes that travelers would likely make in response to the safety/mobility impacts?

Travel decisions reflect the changes that travelers may need to make to their travel plans based on how those plans are affected by the weather event. The information needed to properly support these travel decisions constitutes travelers' basic information needs. For example, if travelers find out that the highway they were intending to take later in the trip is closed, the primary information that they need to know is what alternative routes are available or should be taken. For travelers currently on the road, finding an alternative route is the most important trip modification; however, for travelers who have yet to depart on their trip, they may also benefit from knowing if they should expect delays or from knowing information that allows them to consider cancelling their trip altogether.

The goal in making this type of information readily available, or notifying drivers directly (e.g., in the case of visibility or traction problems) is to help drivers avoid making poor travel decisions. In particular, if a road weather message clearly communicates the information that travelers are seeking, it will be helpful to them and they will be able to make more informed decisions about changes to their travel plans or behavior. However, if a message cannot provide the needed information, then travelers will either ignore the message or be required to look elsewhere for the information they need. A related factor is the willingness of travelers to make certain travel decisions (additional detail regarding this issue is available in Tutorial 1).

A list of primary travel decision that travelers might make in response to safety/mobility impacts includes:

- Should they expect and plan for delays?
- Should they use an alternative route?
- Should they change travel modes (e.g., drive vs. take transit)?
- Should they drive with greater caution?
- Should they change their driving behavior because of hazardous conditions?
- Should they make special safety-related preparations (e.g., pack special supplies, bring tire chains, etc.)?
- Should they cancel their trip?

The Travel Decision Table (Table 30 in Step 2) maps out the relationship between these travel decisions and each safety/mobility impact described in the previous step. Two categories are used to describe the relationship between a travel decision and mobility impact. The term "likely" is used to indicate a likely or primary travel decision that needs to be made in response to a safety/mobility impact. The term "possible" is used to indicate a travel decision that could be applicable, but does not represent a key decision. It may be a convenience to travelers, but not a priority, to make information available for “likely” travel decisions. One important caveat associated with Table 30 is that the likelihood assignments (e.g., “likely”, “possible”) are currently based on expert judgment and have not been empirically validated (see the Task 4 Report for further discussion (Richard et al., 2009)).

Question 4: What Dissemination Methods are most suitable given the Traveler’s situation?

The dissemination methods represent the primary methods for providing road weather information to travelers. These methods also complicate the process of communicating to travelers because they vary substantially with regard to what type of and how much information can be provided. Furthermore, travelers will have access to different dissemination methods at different points during their travel planning and during their trip.

One consideration is that the suitability of specific dissemination methods will vary depending on the travel situation. For example, some methods can provide information directly when it is needed, such as route closure and detour information accessed from the internet while a traveler is selecting his or her route, or information on a DMS that alerts drivers of icy road conditions just ahead. In contrast, other situations can involve the use of dissemination methods when they are less suitable, such as when they provide relevant information, but not when it is needed. For example, drivers can be informed about icy roads the day before their trip or just prior to departing; however, since they will not be able to use that information until later in their trip, there is a good possibility that this warning information will be forgotten. In this case, the dissemination methods used to communicate information in this way are ineffective. Tutorial 2 discusses the suitability of making specific travel decisions at various trip stages.

Another way in which a dissemination method may be less suitable is if using it has safety implications. For example, using a personal electronic device to obtain road condition information while driving could pose a driver distraction hazard. Consequently, other dissemination methods should also be available to provide information, so that drivers are not required to use potentially unsafe means to obtain road weather information.

Finally, some dissemination methods are unsuitable for providing certain types of road weather information because of when travelers receive the information. An example of this is using *only* DMS or HAR to communicate information related to delaying or canceling travel. Since travelers would not obtain this information until they were already on the road, they obviously could not use this information to make the appropriate travel decisions during the planning of their trips. Tutorial 3 discusses the availability of various dissemination methods at different trip stages as well as traveler awareness and preferences for different dissemination methods.

The key point is that not all dissemination methods are equally useful for presenting certain types of road weather information; however, the suitability of each method also depends on the trip stage and other aspects of the travel situation. The Travel Decision Table (Table 30 in Step 2), provides a way to identify the most suitable dissemination methods for particular travel decisions. The definitions regarding the suitability of dissemination methods are based on limited categorizations at this point, due to limited existing research information. Table 28 below summarizes the three categories.

An additional note is that the category of "text messaging" was included as a dissemination option in this table. To clarify, the text messaging option would represent any technology that sends a brief message to travelers via a portable electronic device. This could also include newer communication formats, such as "Twitter" that involve a similar short message sent to subscribers. The key descriptive feature in these approaches is that information is sent to the traveler, which means that the timing of information communication is predominately outside of the traveler's control. In contrast, the category of personal electronic device (PED) is used to represent a collection of portable devices that travelers can use to actively acquire information when they want it. In this case, the timing information communication is fully under the traveler's control (note that technologies such as "Twitter" contain elements of both, since travelers can choose when to check for new messages). Another important point that should be noted is that "pushing" messages on travelers while they are driving may pose a safety hazard, and several jurisdictions are considering passing or enacting laws against using text messaging while driving.

Table 28. Definition of the "suitability" category for dissemination methods in Table 30.

Category	Definition
Suitable	Dissemination method typically makes road weather information available when 1) drivers actually need it to make decisions, and 2) they can safely access the information
Suboptimal	Dissemination method typically makes road weather information available 1) well before when travelers need it to make decisions, which makes it easier to forget, and/or 2) accessing the information may be a safety concern (e.g., driver distraction)
Unsuitable	Dissemination method makes information available when most travelers will be unable to access it when they have to make the relevant travel decision

Optional Step 2a: Look up relevant traveler information needs

The purpose of Step 2a is to provide additional information about the key traveler information needs associated with each travel decision. This step is optional, and provided as a way to identify in more detail what message information is required to more completely support the identified travel decisions. This step helps determine "what" the message should say, in contrast to later steps, which focus on "how" to say it.

Question 5: What are the specific traveler information needs?

When deciding what to do when faced with certain safety/mobility impacts, most travelers will try to make the best decision they can (or at least try to avoid making bad decisions) based on the available information. In most cases, travelers will be depending almost entirely on information from road weather messages, with the exception of what information they can get from their immediate surroundings. Therefore, a prerequisite for helping travelers make sound travel decisions is making sure that they get information that applies to their decision and covers as many relevant aspects as possible.

The information from the recommendations available in this step is applicable to the main content of the message. This information is most useful if there is uncertainty about what a message should communicate such as when developing new messages. Another use is in deciding how to prioritize message information. In particular, the key difficulty in designing messages is often identifying what information elements have to be left out of a message because of limitations associated with the dissemination method (e.g., limited resolution or space on a display). Tutorial 4 provides guidance for prioritizing information regarding safety/mobility impacts based upon personal safety risks, crash risks, and convenience/schedule impacts for the traveler.

The look-up table (Table 31) provides a “road map” for finding recommendations about specific traveler information needs, which are available in Appendix E.

Step 3: Lookup relevant design recommendations

The purpose of Step 3 is simply to point an end-user or message designer to the relevant design recommendation information, once they have identified the specific dissemination methods, and other weather event information (e.g., timeframe) that they want to communicate.

Question 6: For the specified Dissemination Methods, which human factors design guidelines apply to the message content and presentation format?

The look-up table in Step 3 provides a way to find message design guidelines that apply to the identified dissemination methods. The idea is that an end-user would use the relevant dissemination method class to look up the page numbers of the applicable design guidelines shown in the table cell. The specific content of the message should be consistent with the associated travel decisions. Recommendations for identifying information that supports travel decisions are available in Step 2a.

Note that in order to reduce the complexity of the table, dissemination methods were grouped by the base format, such as short text messages (e.g., DMS), open visual formats (e.g., web-pages), and auditory messages (e.g., HAR, 511). Although specific design recommendations may not be identical for dissemination methods within a class, they are similar enough that the basic design principles should still apply across methods. Clear exceptions are noted in the discussion section of applicable guidelines.

Step 4: Apply design recommendation information

Question 7: What are the specific design recommendations?

The design guidelines contained in a separate chapter represent the primary information provided by the design tool. They include recommendations regarding the content and display format/layout of weather message information tailored for certain types of dissemination methods. These recommendations are based on the best available information; however, because there is a lack of data specific to road weather information, much of this guidance has been extrapolated from more general human factors design principles. Nevertheless, the objective was to provide as specific of recommendations as possible to promote the design of road weather messages that support sound traveler decision-making during weather disruptions. Additionally, these guidelines provide recommendations for presenting that information in a way that is easy to read/hear and understand for the selected dissemination methods and the situational constraints that travelers may face when obtaining that information (e.g., reading distance requirements for DMS).

Complete Process for Finding Relevant Message Design Recommendations

The complete process for finding design information is shown in Figure 28 below and the corresponding look-up tables for each step follow the table. It essentially involves 4 main steps and one optional step. These include:

1. Use Table 29 to identify primary safety/mobility impacts of concern for the impending weather event.
2. For the selected safety/mobility impacts, look up the *likely* and *possible* travel decisions in Table 30, and the dissemination methods that are identified as being *suitable/acceptable* for reaching travelers.

   2a. If additional guidance is required about what the message content should be to support traveler decision making, use Table 31 (Traveler Information Needs Look-up Table) to find recommendations in Appendix E.
3. Use the Table 32 look-up table as a “road map” to find message design recommendations provided later in this chapter based on the identified types of dissemination methods.
4. Refer to the specific design recommendations in the current chapter for “design tips” that promote clear and effective understanding of road weather messages.

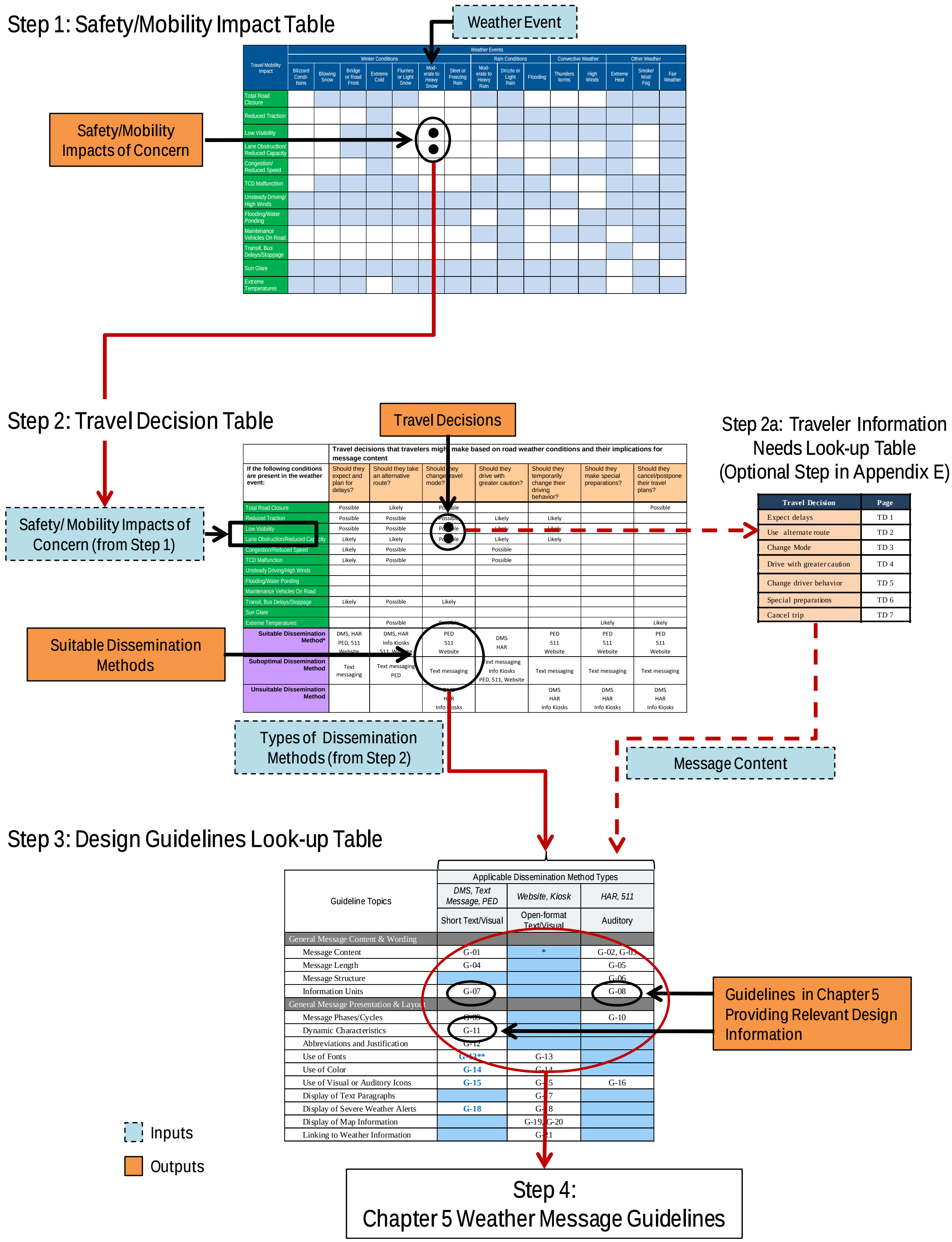


Figure 28. Schematic diagram showing the relationship between the key tables and the inputs and outputs used in each step of the message design tool.

Table 29. Step 1 – Safety/Mobility Impact Table – Identify safety/mobility impacts of concern (rows) for a weather event (columns).

Safety/Mobility Impact	Weather Events															
	Winter Conditions								Rain Conditions			Convective Weather		Other Weather		
	Blizzard Conditions	White-out Conditions	Blowing Snow	Bridge or Road Frost	Extreme Cold	Flurries or Light Snow	Moderate to Heavy Snow	Sleet or Freezing Rain	Moderate to Heavy Rain	Drizzle or Light Rain	Flooding	Thunderstorms	High Winds	Extreme Heat	Smoke/ Mist/ Fog	Fair Weather
Total Road Closure																
Reduced Traction																
Low Visibility																
Lane Obstruction/ Reduced Capacity																
Congestion/ Reduced Speed																
TCD Malfunction																
Unsteady Driving/ High Winds																
Flooding/Water Ponding																
Maintenance Vehicles On Road																
Transit, Bus Delays/Stoppage																
Sun Glare																
Extreme Temperatures																

Note: The shaded cells represent Weather Event and Mobility Impact combinations that are unlikely to occur. This is done to make this table easier to use, however, there is no specific reason to preclude selecting a shaded combination if it makes sense to do so based on conditions.

Next go to Step 2: Match Safety/Mobility Impacts of concern (row headers) with corresponding impacts in Table 30 (Traveler Information Table).

Table 30. Step 2 – Travel Decision Table – Identify travel decisions and suitable dissemination methods for each safety/mobility impact of concern.

	Travel decisions (TDs) that travelers might make based on road weather conditions and their implications for message content						
If the following conditions are present in the weather event:	Should they expect and plan for delays (TD 1)?	Should they take an alternative route (TD 2)?	Should they change travel mode (TD 3)?	Should they drive with greater caution (TD 4)?	Should they change their driving behavior (TD 5)?	Should they make special preparations (TD 6)?	Should they cancel/postpone their travel plans (TD 7)?
Total Road Closure	Possible	Likely	Possible				Possible
Reduced Traction	Possible	Possible	Possible	Likely	Likely	Likely	
Low Visibility	Possible	Possible	Possible	Likely	Likely		
Lane Obstruction/Reduced Capacity	Likely	Likely	Possible	Likely	Likely		
Congestion/Reduced Speed	Likely	Possible		Possible			
TCD Malfunction	Likely	Possible		Possible			
Unsteady Driving/High Winds				Possible	Likely		
Flooding/Water Ponding	Possible	Likely		Possible	Likely		Possible
Maintenance Vehicles On Road	Possible			Possible	Likely		
Transit, Bus Delays/Stoppage	Likely	Possible	Likely				
Sun Glare				Likely	Possible		
Extreme Temperatures		Possible	Possible			Likely	Likely
Suitable Dissemination Method**	DMS, HAR PED, 511 Website	DMS, HAR Info Kiosks 511, Website	PED 511 Website	DMS HAR	PED 511 Website	DMS***, HAR*** PED, 511 Website	PED 511 Website
Suboptimal Dissemination Method	Text messaging	Text messaging PED	Text messaging	Text messaging Info Kiosks PED, 511, Website	Text messaging	Text messaging	Text messaging
Unsuitable Dissemination Method	None	None	DMS HAR Info Kiosks	None	DMS HAR Info Kiosks	Info Kiosks	DMS HAR Info Kiosks

* Note: Could be likely, but it depends on the severity of the conditions.

** Note: Commercial TV/Radio are excluded because the presentation of information is outside of the control of transportation professionals.

***Note: DMS and HAR work for preparations such as putting on chains, but not for preparations where the traveler needs to bring items from home.

Next go to Step 2a (Optional): Use Table 31 below to determine where to find additional recommendations about traveler information needs.

OR Step 3: Use Look-up Table 32 to find design recommendations related to selected travel decisions and suitable dissemination methods.

Table 31. Step 2a – Traveler Information Needs Look-up Table showing where to find information about each travel decision.

Travel Decision	Page
Expect delays	Travel Decision 1, page E-3
Change route	Travel Decision 2, page E-6
Change travel mode	Travel Decision 3, page E-10
Drive with caution	Travel Decision 4, page E-13
Change driving behavior	Travel Decision 5, page E-16
Make safety-related preparations	Travel Decision 6, page E-20
Cancel trip	Travel Decision 7, page E-24

Next go to Step 3: Use Look-up Table 32 to find design recommendations related to selected travel decisions and suitable dissemination methods.

Table 32. Step 3 – Design Guidelines Look-up Table – The guideline numbers (G-XX) in each cell indicate where to find design recommendations for each type of dissemination method.

Guideline Topics	Applicable Dissemination Method Types		
	DMS, Text Message, PED	*Website, Kiosk*	*HAR, 511*
	Short Text/Visual	Open-format Text/Visual	Auditory
General Message Content & Wording			
Message Content	G-01	*	G-02, G-03
Message Length	G-04		G-05
Message Structure			G-06
Information Units	G-07		G-08
General Message Presentation & Layout			
Message Phases/Cycles	G-09		G-10
Dynamic Characteristics	G-11		
Abbreviations	G-12		
Use of Fonts	**G-13****	G-13	
Use of Color	**G-14**	G-14	
Use of Visual or Auditory Icons	**G-15**	G-15	G-16
Display of Text Paragraphs		G-17	
Display of Severe Weather Alerts	**G-18**	G-18	
Display of Map Information		G-19, G-20	
Linking to Weather Information		G-21	
Traffic Camera Displays		G-22	
Accommodating other web-based dissemination methods	G-23	G-23	
Use of Table Information		G-24	
Communicating Timeframe	G-25	G-25	G-26
Communicating Geographic Extent	G-27	G-19, G-20	G-28
Communicating Degree of Urgency	G-29	G-29	G-29
Communicating Degree of Certainty	G-30	G-30	G-30

*Blank, shaded cells indicate that a guideline topic is not applicable or there is insufficient information to provide one.

**Guidelines indicated in blue bold apply only to non-DMS short message dissemination methods.

Next to go Step 4: Look up the relevant page numbers in Chapter 5: Road Weather Message Design Recommendations.

Weather Message Guidelines

IMPORTANT NOTE: There is an important caveat about providing short text message information that can be accessed over Portable Electronic Devices, such as cell phones. Trying to use these devices while driving is a distraction. An Executive Order prohibits text messaging while driving by Federal Employees using Government property or on official Government business (Executive Order No. 13,513, 2009). The USDOT also recognizes distraction as a serious safety concern (http://www.distraction.gov/dot/). In addition, state laws pertaining to the use of certain Portable Electronic Devices while driving may apply. Consult applicable legislation and policy when designing information that could be used on these devices.

Exec. Order No. 13,513, 74 Fed. Reg. 51,225 (Oct. 1, 2009).

GUIDELINE 01. MESSAGE CONTENT – SHORT TEXT/VISUAL

Introduction

Message content for short text/visual messages refers to the specific text used in messages.

Design Guidelines
• Provide a specific diversion route if available • Provide precise incident location information if available • Do not use signal words such as: Danger, Warning, Caution • Avoid the use of symbols

Discussion

Message specificity is a message property that is affected by many different message aspects including space available on the sign, the information available to the TMC, information unit limits, and message length limits. Wang, Collyer, and Yang (2) found through participant questionnaires for DMS that more specific messages (i.e. "Flooding at Exit 12, Major Delays to Boston, Use Route I-295) are preferred to less specific messages (i.e. "Flooding at Exit 12, Major Delays, Use other Routes). Pedic (3) also reports that drivers are more likely to correctly interpret a message when it includes a specific diversion task instead of a generic diversion task. Drivers are also more willing to divert if given the incident location, expected delay, and best detour strategy rather than just a subset of that information (4). Survey data shows that precise location information was preferred so drivers could make informed decisions about exiting/re-entering the roadway (5). When expressing exit information, "This Exit" instead of "Next Exit" was preferred to refer to the upcoming exit (5).

When forming messages, prefacing the message with a signal word (e.g., danger, warning, caution) does not affect driver performance (1). Additionally, these words may not be interpreted as intended. Avoiding the use of such words can reduce reading time, conserve sign space, and prevent driver confusion. However, using the word caution as part of a recommended action (e.g. "Use Caution") is acceptable.

Another aspect that affects comprehension is the use of symbols. Symbols can convey information without requiring driver literacy. In general, symbolic signs are recognized better, faster, and from further away than the corresponding text signs (1). However, care should be taken in their use since the meaning of symbolic signs is not always as well understood. Additionally, symbols may not be part of the standard font used on some devices, rendering the information useless to some users (travelers). Twitter currently does not support the use of pictures and character-based symbols are not recommended. Using DMS to display television pictures of conditions or maps was not positively received by a majority of survey respondents (5).

Key References

1. Proffitt, D. R., and Wade, M. M. (1998). *Creating effective variable message signs: Human factors issues.* (Report No. VTRC 98-CR31). Charlottesville: Virginia Transportation Research Council.
2. Wang, J.-H., Collyer, C. E., and Yang, C.-M. (2005). *Enhancing motorist understanding of variable message signs.* (Report No. FHWA-RIDOT-RTD-06-1). Providence: Rhode Island Department of Transportation.
3. Pedic, F., and Ezrakhovich, A. (1999). A literature review: The content characteristics of effective VMS. *Road & Transport Research, 8(2)*, 3-11.
4. Peeta, S., Ramos, J. L., and Pasupathy, R. (2000). Content of variable message signs and on-line driver behavior. *Transportation Research Record, 1725*, 102-108.
5. Benson, B. G. (1996). Motorist attitudes about content of variable-message signs. *Transportation Research Record, 1550*, 48-57.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 02. MESSAGE CONTENT – AUDITORY

Introduction

Message content for auditory messages refers to the specific words and phrasing of an auditory message. The following message content elements do not necessarily need to be presented in the order given.

Design Guidelines

Message Content Elements	Examples (adapted from Reference 1)
Begin a message by getting the driver's attention* • Start with the word "Attention" followed by the destination group (identified by direction of travel and name of facility) and the word "Traffic"	• "Attention Eastbound Interstate 10 Traffic" • "Attention Eastbound US 59 and Southbound Interstate 410 Traffic"
State the severity of the problem, but only briefly	• "Snowfall and high winds have caused drifting snow and limited visibility"
Follow the incident descriptor with information that the driver does not need to remember (such as a good reason for following the advice). Do not follow the incident descriptor with diversion directions.	• On I-94 between Exit 67 and Exit 97 • Be prepared for difficult driving conditions • Look out for snow patches on the roadway • The road is slippery
Provide at least one good reason for following the advice	• "To Avoid a Major Delay" • "To Avoid 20 Minutes Delay" • "To Save 15 Minutes" • "To Avoid Heavy Congestion"
Tell the driver the location of the incident	• "For westbound travelers on I-90 between Factoria and Seattle, travelers can expect road conditions as follows…"

* This guideline is only suitable for HAR messages since users (travelers) are likely to have already navigated a 511 menu structure before reaching this information.

Discussion

Drivers are more concerned about what they should do than the severity of the problem (1). Thus, the severity should only be stated briefly, to alert drivers to pay attention to the subsequent information.

Huchingson et al. (1) recommend that the driver be given time to think about the problem statement before hearing more information that is imperative for them to recall. A positive reason for following the advice given or a phrase such as "You are Advised to" directly following the problem statement is suggested.

Huchingson et al. (1) also suggest that at least one good reason should be provided for following the advice that is given. This statement provides incentive beyond those implied by words such as "Flooding" or "Icy Roads". The phrase "Major Delay" implies a delay of at least 20 minutes to drivers.

The location of the incident should be given if appropriate to assist drivers with choosing where to exit (1). However, non-local drivers who are not familiar with the street names would benefit from a location presented in terms of major highways or landmarks. Huchingson et al. (1) recommend that if the specific location is unknown, the incident descriptor followed by "Ahead" is sufficient, placing priority on fast information dissemination.

Key References

1. Huchingson, R.D., Dudek, C. L., and Dorsey, W. (1982). *Highway advisory radio message development guide* (Report No. FHWA/RD-82/059). Washington, DC: Federal Highway Administration.

GUIDELINE 03. MESSAGE CONTENT FOR DIVERSION DIRECTIONS – AUDITORY

Introduction

Diversion direction message content for auditory messages refers to the specific words and phrases used when describing diversion routes to drivers.

Design Guidelines

- Use route describers and specific directions for unfamiliar drivers
- Do not include the number of traffic signals as a route describer if one or more are inoperative or flashing
- Use freeway exit numbers if they are available
- Familiar drivers do not need turn directions (e.g. left, right)

Examples of diversion messages for unfamiliar and familiar drivers (adapted from Reference 1)

Unfamiliar Drivers	Familiar Drivers
Exit at Fredericksburg and take the following route:	Exit at Fredericksburg and take the following route:
Turn right on Fredericksburg and go to the fourth stoplight, Wurzbach.	Fredericksburg to Wurzbach
Turn left on Wurzbach and continue past the medical complex to Evers Road. There is a gas station on the left at Evers.	Wurzbach to Evers
Then turn left on Evers and proceed back to Interstate 410 West	And Evers back to Interstate 410 West

Discussion

When providing diversion information, unfamiliar drivers benefit from landmarks in the route information (1). These can include service stations, restaurants, water towers, traffic lights and other prominent landmarks. However, if one or more of the traffic lights along the route are flashing or out of service, the number of traffic lights should not be used as a direction. Additionally, unfamiliar drivers need specific instructions on how to avoid an incident rather than to be left to find their way. It is helpful to tell the driver if a turn is at the first signal or to provide the correct travel lane for a turn if the signs are small (1). If 85% or more of the drivers are familiar drivers, turn directions may be omitted to save time and space. Other optional elements include the length of the detour and the additional time required by the detour (if known).

Key References

1. Huchingson, R.D., Dudek, C. L., and Dorsey, W. (1982). *Highway advisory radio message development guide* (Report No. FHWA/RD-82/059). Washington, DC: Federal Highway Administration.

GUIDELINE 04. MESSAGE LENGTH – SHORT TEXT/VISUAL

Introduction

Message length is defined by the number of words or characters in a message, excluding prepositions.

Design Guidelines

- Keep messages as short and concise as possible
- Use no more than 8 words (excluding prepositions) per message for drivers at high speeds.

Example Message:

Blowing Snow Past Mercer Tune Radio to 530 AM*

*Acceptable message length because the preposition “to” does not count.

Discussion

The appropriate absolute message length is affected by (1):

- The amount of time that the driver is in the legibility zone of the sign (if the sign is outside of the vehicle), considering travelling speed and environmental conditions
- The driver workload including all driver activities such as reading signs, lane positioning, etc.
- Message familiarity because drivers take more time to read unfamiliar content or unusual messages

The 8 word maximum for high speeds is based on the legibility distance, or the distance at which the words on the sign become legible, as well as the speed that the driver is travelling. This recommendation assumes drivers are traveling at 55 mi/hr and the legibility distance of the sign is 650 feet (2). It is also based on the required reading time of 1 second per 4-8 character word, excluding prepositions, or 2 seconds per information unit, whichever is longest. If the message is too long for drivers to read at normal speeds, it is likely that some drivers will slow down to be able to read the message, affecting the traffic flow (1). In general, the message length should be reduced as much as possible without losing the message intent (1). This can be accomplished by using alternate phrases or appropriate abbreviations, and removing redundant and unimportant information.

This guideline is based upon dynamic message signs which are outside of the vehicle. The time available to read these signs is limited by the amount of time before the driver passes the sign, whereas messages on other devices, such as PED, are not limited by this same factor. However, they are still limited by the physical parameters of the dissemination method (such as display size and font size) and the traveler capabilities (such as visual acuity and memory limitations). Note that with PEDs the intended use should be to provide information to a traveler when he or she is not driving. An important difference from DMS is that PED and Twitter can display full sentences with supporting words in contrast to DMS, which cannot. However, note that Twitter has a 140 character limit per message. It is also important for these dissemination methods to include appropriate punctuation to facilitate understanding since the message may not divided into multiple lines as it is on DMS. Further discussion of these issues is included in the guideline for information units on short text/visual devices.

Key References

1. Dudek, C. L. (2004). *Changeable message sign operation and messaging handbook* (Report No. FHWA-OP-03-070). College Station, TX: Texas Transportation Institute.
2. Dudek, C. L. (1992). *Guidelines on the use and operation of changeable message signs* (Report No. FHWA-TX-92-1232-9). College Station: Texas Transportation Institute.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 05. MESSAGE LENGTH – AUDITORY

Introduction

The message length of an auditory message is either the number of syllables, words, or sentences necessary for presenting auditory information to the driver. Depending on the type of information being presented, different message lengths are acceptable.

Design Guidelines
• Be as concise as possible • Use concise messages rather than conversational messages • Avoid interesting but unnecessary information • If the message is long, place the critical information near the beginning

Example of a concise message and a corresponding conversational message (adapted from Huchingson, Dudek, & Dorsey (1))

Concise Message	Conversational Message
• Attention southbound Interstate 5 traffic • There is flooding between Washington State Route 599 and Washington State Route 518 • Expect congestion and delays ahead	• Attention all traffic headed south on Interstate 5 • This is your Washington Highway Advisory Radio coming to you from traffic control headquarters, 1660 kilohertz on your dial • You are advised that there is flooding between Washington State Route 599 and Washington State Route 518 just north of the Seattle-Tacoma International Airport • This flooding is causing traffic congestion and will result in some delay in your travel time on Interstate 5 • Be alert for slowing vehicles • Please drive safely and thank you for listening to the Washington Highway Advisory Radio system for timely traffic reports

Discussion

There is a trade-off between providing essential information to drivers and maintaining a reasonable message length. Huchingson et al. (1) report that drivers prefer short auditory messages to conversational style messages. The conversational message broadcasts additional unnecessary information such as the radio station and a statement thanking the driver for listening. The conversational message uses many more words to get the same points across to drivers. Long messages may be necessary in some situations, but they should convey more points than the shorter messages and remain concise.

Messages should be as concise as possible while still conveying the necessary information. Interesting information that is unnecessary to the driver should be avoided (1). If the message is long, the most critical information should be placed at the beginning of the message. This will allow travelers who only want the most critical information to hang up and avoid tying up the 511 line.

Key References

1. Huchingson, R.D., Dudek, C. L., and Dorsey, W. (1982). *Highway advisory radio message development guide* (Report No. FHWA/RD-82/059). Washington, DC: Federal Highway Administration.

GUIDELINE 06. MESSAGE STRUCTURE – AUDITORY

Introduction

The structure of an auditory message refers to the structure, timing, and order of the elements that are to be presented in the message. Some of the following guidelines apply only to messages that are recorded by human operators, though many also apply to messages that are created by an automated system.

Design Guidelines

- Use sentences instead of isolated words
- Message delivery:
  - Choose a male or female announcer with an average to low-pitched voice
  - Deliver the message in a calm, matter of fact, dignified manner
  - Stress information that the driver needs to recall such as street names and turn directions
  - Enunciate proper names carefully
  - Pause 1 second after each statement (e.g. Attention statement, problem statement) except in the following situations:
    - Pause ½ second after the phrase "To Avoid Major Delay" if used
    - Pause 2 seconds if repeating the message, before and after the statement "I Repeat"
    - Pause only ½ second between street names if the message is read without turn directions (i.e. to familiar drivers, see Guideline 03)
  - Deliver the message at approximately 175 words per minute

Discussion

The order of the elements in an auditory message is important. The information that is the most important should be presented at the beginning or end of the message since that position makes it easier to recall (1).

Huchingson, Dudek, and Dorsey (2) provide guidance for message delivery. The message should sound official. The information that the driver needs to recall needs to be well understood. The speed of the message delivery is also important. Any speed below 110 words per minute sounds dragged out while speeds over 200 words per minute may not be understood by some drivers (2).

Most of the guidance presented above applies to HAR rather than 511 messages. For example, it is not necessary to get the traveler's attention when they are listening to a 511 message since they called into the system. Additionally, they may be given the option to repeat by the phone system rather than forced to listen to a repeat of the message. In 511 systems, many of the messages are automated or prerecorded. These guidelines may not apply to those messages, but provide some guidance for the initial design of those messages.

Key References

1. Campbell, J. L., Carney, C. and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (Report No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

2. Huchingson, R.D., Dudek, C. L., and Dorsey, W. (1982). *Highway advisory radio message development guide* (Report No. FHWA/RD-82/059). Washington, DC: Federal Highway Administration.

GUIDELINE 07. INFORMATION UNITS – SHORT TEXT/VISUAL

Introduction

Information units measure the amount of information presented in terms of facts used to make a decision.

Design Guidelines

Use no more than:

- 2 information units per line
- 3 information units per phase
- 4 information units per message read at speeds of 35 mi/h or more
- 5 information units per message read at speeds less than 35 mi/h

Examples of information units (adapted from Dudek (1)):

Question	Answer (1 information unit)
What is the problem?	FLOODING
Where is the problem?	AT US-23
Who is the message for?	NEW YORK
What should they do?	USE I-280 EAST

Discussion

The recommendations for the number of information units that are appropriate for display are based on research and operational experience with dynamic message signs (1). Dudek (2) summarizes that 1 second is needed per 4-8 character word excluding prepositions; or, 2 seconds per information unit, whichever is longest. If there are too many information units in the message, Dudek (1) provides guidance for reducing the number of information units in a message.

Note that this method is not the only method used to count information units. The ATIS Guidelines (3) provide a word-by-word method to count information units (generally the "relevant words" in the message, often counting each word that is not a preposition as one unit). The method proposed by Dudek is supported here since the weather messages are more structured in nature, like the dynamic message sign messages from Dudek (1).

Key References

1. Dudek, C. L. (2004). *Changeable message sign operation and messaging handbook* (Report No. FHWA-OP-03-070). College Station, TX: Texas Transportation Institute.
2. Dudek, C. L. (1992). *Guidelines on the use and operation of changeable message signs* (Report No. FHWA-TX-92-1232-9). College Station: Texas Transportation Institute.
3. Campbell, J. L., Carney, C. and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (Report No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 08. INFORMATION UNITS FOR DIVERSIONS – AUDITORY

Introduction

An information unit in an auditory message describing a diversion is defined as a street name or turning movement.

Design Guidelines
Diversion information should be a maximum of 8 information units. Examples of information units for a diversion message (each unit is underlined, from Huchingson, Dudek, & Dorsey (1)): Turn right on Jackson Then left on San Pedro and Proceed back to Interstate 410 East (implied turn right onto the Interstate) Total = 6 information units

Discussion

Huchingson et al. (1) reported that 90% of unfamiliar drivers can follow a diversion route containing 6-8 information units with no errors. When drivers return to their initial roadway, it is not necessary to tell them which direction to turn since they will know which direction they were originally headed. It is recommended that routes requiring ten or more information units be avoided. If such a complex route is necessary, drivers should be directed to exit the roadway by the message and then guided through the diversion route by trailblazers. A ten unit diversion route should not be described in an auditory message (1).

Key References

1. Huchingson, R.D., Dudek, C. L., and Dorsey, W. (1982). *Highway advisory radio message development guide* (Report No. FHWA/RD-82/059). Washington, DC: Federal Highway Administration.

GUIDELINE 09. MESSAGE PHASES/CYCLES – SHORT TEXT/VISUAL

Introduction

A phase is a measure of the text that is displayed at a single point in time, similar to a page of a book.

Design Guidelines
• 2 phases maximum per message • Each phase must be able to be understood alone • When dividing messages between two phases, compatible information units should be kept in the same phase • 1 line should not contain parts of 2 information units but may contain 2 whole information units

Examples of poor and improved message phases (adapted from Dudek (1)):

Poorly Designed Message		Improved Message	
Phase 1	**Phase 2**	**Phase 1**	**Phase 2**
Flooding At US-23 New York	Use I-280 East	Flooding At US-23	New York Use I-280 East

Discussion

Dudek (1) reports that drivers have difficulty reading dynamic message sign messages that are on more than two phases. Since either phase 1 or phase 2 may be read first by a passing driver, each phase should make sense by itself. This is accomplished by keeping compatible information units in the same phase. When drivers read the sign, displaying portions of two different information units on a single line is confusing and increases reading time (1).

This guidance does not apply to non-DMS messages since drivers should not be expected to use PEDs while driving.

Key References

1. Dudek, C. L. (2004). *Changeable message sign operation and messaging handbook* (Report No. FHWA-OP-03-070). College Station, TX: Texas Transportation Institute.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 10. MESSAGE PHASES/CYCLES – AUDITORY

Introduction

A cycle is a single repetition of the entire auditory message. This guideline mainly applies to HAR messages since 511 listeners may be given the option to repeat by the phone system rather than forced to listen to a repeat of the message.

Design Guidelines

- Play a 3-5 second non-verbal sound between cycles
- Repeat the turning directions and street names if they are included in a diversion message, using internal or external redundancy, shown below (adapted from Huchingson, Dudek, &Dorsey (1)).

Approach #1: Internal Redundancy	Approach #2: External Redundancy
• Attention westbound Interstate 410 traffic • There is flooding ahead • To avoid major delay • Exit at Fredericksburg, and take the following route: • Turn right on Fredericksburg, • And continue to Wurzbach • Turn left on Wurzbach • And then continue to Evers • Turn left again on Evers • And proceed back to Interstate 410 West	• Attention westbound Interstate 410 traffic • There is flooding ahead • To avoid major delay • Exit at Fredericksburg, and take the following route: • Turn right on Fredericksburg, • Then turn left on Wurzbach • And then turn left again on Evers, • And proceed back to Interstate 410 West I repeat, • Exit at Fredericksburg, and take the following route: • Turn right on Fredericksburg, • Then turn left on Wurzbach • And then left again on Evers, • And proceed back to Interstate 410 West

Discussion

Huchingson et al. (1) recommend that a 3-5 second sound plays between cycles of a message. It is important for drivers to know where they are in the message so that they know when the message begins and ends. Also, if they start listening between message cycles, the sound lets them know that they are tuned to the correct station. The sound can be an alert, such as a pulsating beep, or a combination of unique tones (1). Huchingson et al. (1) also recommend the repetition of street names either within the message (approach #1) or after the message (approach #2) since they are often difficult to hear with other ambient driving noise. However, for 511 messages, instead of automatically repeating the directions, the user (traveler) may be given the option to say "repeat" at the end of the message to hear the directions again.

Key References

1. Huchingson, R.D., Dudek, C. L., and Dorsey, W. (1982). *Highway advisory radio message development guide* (Report No. FHWA/RD-82/059). Washington, DC: Federal Highway Administration.

GUIDELINE 11. DYNAMIC CHARACTERISTICS – SHORT TEXT/VISUAL

Introduction

Dynamic characteristics for message presentation of short text/visual messages refer methods used to transition between text frames or portions of messages.

Design Guidelines

Topic	Definition	Guideline	Rationale/Source
Phase Display Time	The amount of time to display each phase of a two-phase message	Use 2 seconds per information unit OR 1 second per 4-8 character word, whichever is longest	Research and field experience (1)
Blank Time between Phases	The amount of time that a display is left completely blank between message phases	Insert a 300 ms blank screen between message phases 1 and 2	Increased word and number comprehension (2)
Flashing Messages	One phase messages which flash the entire message	Do not use	Disagreement in research results (3, 4)
	One phase messages which contain one flashing or blinking line	Do not use	Increased reading time and reduced comprehension (3, 4)
Alternating-line Messages	Multiple phase messages in which only a subset of the lines change between phases	Do not use	Increased reading time (3, 4)
Looming	Increasing text or symbol size over time	Do not use	No positive effect (2)

Discussion

Most of the research that forms the basis of this guideline is for dynamic properties of dynamic message signs. However, many of the dynamic properties that are possible with these signs are also probably available for other short text devices. The amount of time that a single phase should be displayed is determined by the amount of content in that phase. Dudek (1) summarizes that 1 second is needed per 4-8 character word excluding prepositions; or, 2 seconds per information unit, whichever is longest. Also, Greenhouse found that inserting a 300 ms blank screen between phase 1 and phase 2 of a portable message sign improves comprehension (2). This is possibly because a refractory period helps information processing between screens. However, it is reasonably conceivable that drivers, who see a blank between phases 1 and 2 but not between phases 2 and 1, would reverse the order of the phrases and possibly have trouble understanding the message. Dudek (1) recommends that blank time and/or asterisks be displayed between cycles of a message that contains 3 or more phases (on one-word or one-line signs). Since these signs are more limited in the amount of information that they can display at one time, the phases may not make sense independently and drivers who read later phases before phase 1 may not understand the message. Thus, giving an indication of where the message is in the cycle, gives drivers an idea of their location in the cycle.

There are many ways in which all or portions of messages can be flashed or moved in an attempt to draw driver attention. Flashing one phase of a message caused differing results in the laboratory and simulator (3, 4), and thus is not recommended. Flashing one line (most often the last line) of a message negatively affected comprehension levels and reading times (3, 4) and is also not recommended. In alternating-line messages, a portion of the message is held constant between the two phases (usually the first two lines) while the other portion is alternated between two pieces of information (usually the third line). Research (3, 4) on this method showed that although comprehension was not affected, reading times greatly increased. In a study by Greenhouse (2), looming did not help any group of drivers comprehend messages. It also functioned as a driver distraction and had a negative effect on intelligibility.

Key References

1. Dudek, C. L. (1992). *Guidelines on the use and operation of changeable message signs* (Report No. FHWA-TX-92-1232-9). College Station: Texas Transportation Institute.
2. Greenhouse, D. (2007). *Optimizing comprehension of Changeable Message Signs (CMS)* (Report No. UCB-ITS-PRR-2007-24). Berkeley: University of California Partners for Advanced Transit and Highways (PATH).
3. Dudek, C. L., and Ullman, G. L. (2002). Flashing messages, flashing lines, and alternating one line on changeable message signs. *Transportation Research Record, 1803*, 94-101.
4. Dudek, C. L., Schrock, S. D., and Ullman, G. L. (2005). *Impacts of using dynamic features to display messages on changeable message signs* (Report No. FHWA-HOP-05-069). Washington, DC: Federal Highway Administration.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 12. ABBREVIATIONS – SHORT TEXT/VISUAL

Introduction

This guideline for abbreviations provides information on this formatting quality for short text/visual messages. Message abbreviations refer to when to use abbreviations and how to create them.

Design Guidelines
• Avoid using abbreviations whenever possible • If abbreviations are necessary, use approved abbreviations from Section 1A.15 of the MUTCD • If the MUTCD does not include the desired abbreviation, create an abbreviation by removing letters from the end of a word until it is the desired length

Discussion

Abbreviations provide the benefit of reduced message length; however their use is discouraged because they were found to decrease message comprehension (1) and increase reading times (2); however, due to fixed display size and message length recommendations, abbreviations can be necessary to convey the information to the level of specificity desired. Proffitt and Wade (2) report that in a study of sonar operators, they preferred truncated abbreviations over conventional (created by experts) or contraction (vowel removed) abbreviations. Truncated abbreviations proved to have faster response times and improved decoding times with increasing trials.

Key References

1. Greenhouse, D. (2007). *Optimizing comprehension of Changeable Message Signs (CMS)* (Report No. UCB-ITS-PRR-2007-24). Berkeley: University of California Partners for Advanced Transit and Highways (PATH).
2. Proffitt, D. R., and Wade, M. M. (1998). *Creating effective variable message signs: Human factors issues* (Report No. VTRC 98-CR31). Charlottesville: Virginia Transportation Research Council.
3. Federal Highway Administration (FHWA). (2009). *Manual on Uniform Traffic Control Devices (MUTCD)* Washington, DC: Author.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

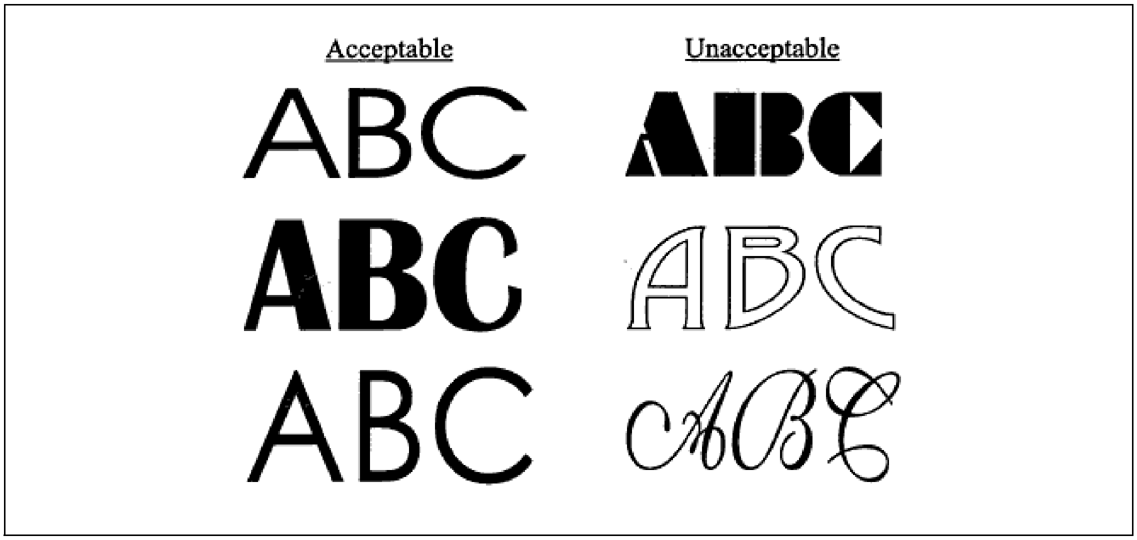
GUIDELINE 13. USE OF FONTS – SHORT TEXT/VISUAL & OPEN-FORMAT

Introduction

Message font for open-format text/visual messages provides information on how to select fonts for use in open format messages. This guidance does not apply to DMSs.

Design Guidelines
Text should be in a clear and simple font. Avoid fonts with excessive flourishes or embellishments.

Examples of acceptable and unacceptable fonts (from Campbell, Carney, & Kantowitz (1))



Discussion

The purpose of font selection is to choose a font that will be easy for users (travelers) to read so that they will not spend extra time reading the text. Most fonts that are clear and simple will be legible if other parameters such as character size and contrast are sufficient (1).

Key References

1. Campbell, J. L., Carney, C. and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (Report No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 14. USE OF COLOR – SHORT TEXT/VISUAL & OPEN-FORMAT

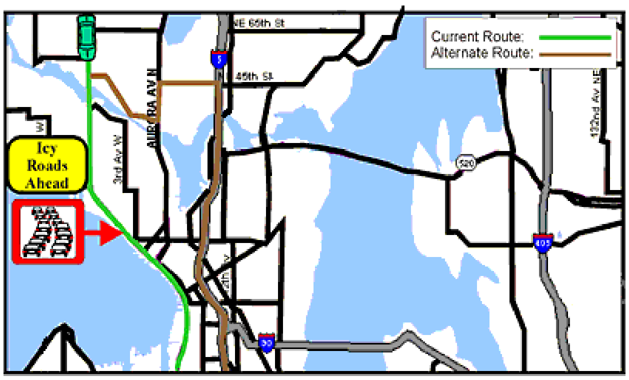
Introduction

Message presentation for open-format text/visual messages refers to the use of color in open-format text/visual displays. This guidance does not apply to DMSs.

Design Guidelines

- Keep the number of colors used to code information to a minimum:
    - 4 colors for casual users (travelers)
    - 7 colors for experienced users (travelers)
- Follow population expectations for color usage:
    - Red: stop, warning, hazard
    - Yellow: caution, wait
    - Green: proceed, OK
- Use color consistently on every display in the system (e.g. every page on a website, every screen for a kiosk).
- Increase object size as the number of colors used increases.
- Keep roads that are not color coded the same color that they would normally be on a paper map.
- Use thicker roads when they are color coded.
- Use compatible color combinations for colors that are presented at the same time. Avoid: red/green, green/blue, blue/yellow, and red/blue pairs unless the goal is to make different parts of the screen appear in different planes.
- Coding map features:
    - Map areas may be coded using texture patterns, color, or tonal codes (different shades of the same color)
    - Use tonal codes rather than different colors when users (travelers) must make relative judgments (i.e. elevations)
    - Order the code values so that the darkest and lightest shades are the most extreme coded values
    - Highlight areas of extra significance that require user attention (i.e. severe storms)

Example of the use of color coding (adapted from Campbell, Carney, & Kantowitz (1)):



Discussion

When using color coding, it is important to keep the number of colors used to a minimum and follow user (traveler) expectations as much as possible. Green et al. (3) suggest that color coded roads be thicker than regular roads since it is easier to identify the color of a larger area and the congestion level of the road may not be the same in each direction.

Coding maps helps to define areas of interest. It may be practical to limit coding to the single most significant variable for the purpose of clarity. When coding areas that require the user (traveler) to perceive relative differences for a single dimension (i.e. elevation changes), use tonal codes. Users (travelers) can order different tones along a continuum, but there is no natural way to order different colors. Before using tonal codes, it should be checked if the electronic display can provide the variation in colors necessary. The tonal codes should be assigned so that the darkest and lightest shades represent the most extreme values represented (i.e. highest and lowest elevations). This ordering will help users (travelers) remember and understand the categories.

In order to meet the needs of travelers with color-blindness, the use of alternative means to represent different conditions, roadways, etc, should be explored. These alternative means could include shading, or cross-hatching or other patterns that do not rely on color.

Key References

1. Campbell, J. L., Carney, C. and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (Report No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.
2. Smith, S.L., and Mosier, J.N. (1986). *Guidelines for designing user interface software*. (Report No. ESD-TR-86-278). Bedford, MA: The Mitre Corporation. Retrieved December 3, 2009, from http://hcibib.org/sam/index.html#top
3. Green, P., Levison, W., Paelke, G., and Serafin, C. (1993). *Suggested human factors design guidelines for driver information systems*. (Report No. FHWA-RD-94-087). McLean, VA. Retrieved from http://www.umich.edu/~driving/guidelines/UMTRI_Guidelines.pdf on December 4, 2009.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 15. USE OF VISUAL ICONS – SHORT TEXT/VISUAL & OPEN-FORMAT

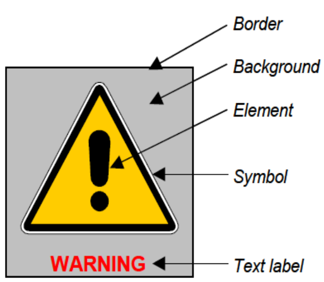
Introduction

Message icons for open-format text/visual displays refers to the selection or design of icons and their labels. This guidance does not apply to DMSs.

Design Guidelines

Icon Property	Guidelines (from Campbell, Richman, Carney, & Lee (1))
Border	• Use a border to show the icon area.
Background	• Don't cover more than half of the available area with objects. • Avoid patterns in the background. • Put the image clearly in front of the background. • Place objects in the center and the background around the periphery. • Use unsaturated, cool colors for the background, and saturated, warm colors for the foreground image. • Keep the background static; if anything blinks or moves, the viewer perceives it as a foreground image. • Limit the background image to a simple rendition of a recognizable, concrete object.
Element	• Use commonly accepted or standardized elements when possible.
Symbol	• Use circles to present prohibition or mandatory information. • Use triangles or diamonds to present warning or cautionary information. • Use squares or triangles to present general information, instructions, or safe condition information.
Text Label	• Use only when necessary, especially when the icon is concept-related or arbitrary. • Limit to two or three words.

Components of an Icon
(from Campbell et al. (1))



Examples of Weather-Related Icons
(from Campbell et al. (1), originally from www.intellicast.com, not intended for use)

Sunny	Windy	Partly Cloudy	Cloudy	Rain	Snow

Discussion

Icon borders and backgrounds are useful to clearly show the users (travelers) which elements are part of the icon. They help define the icon area, show users (travelers) where to click if they are part of a control, and make the icon stand out from surrounding text. However, if the icon is going to be placed over another display such as a map, borders and backgrounds may increase visual clutter and cover other display elements unnecessarily. This could be prevented by removing the border and background. The example icons above have thick symbol borders which would likely provide sufficient contrast against map elements without an additional colored border or background.

Key References

1. Campbell, J. L., Richman, J. B., Carney, C., and Lee, J. D. (2004). *In-vehicle display icons and other information elements. Volume 1: Guidelines.* (Report No. FHWA-RD-03-065). McLean, VA: Federal Highway Administration Retrieved October 6, 2009, from http://www.tfhrc.gov/safety/pubs/03065/03065.pdf.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 16. USE OF ICONS – AUDITORY

Introduction

Auditory icons are “familiar environmental sounds that intuitively convey information about the object or action that they represent” (1). They are also sometimes referred to as naturalistic sounds or earcons. Auditory icons in the context of weather information include thunder claps, wind whistling, raindrops, lightning strikes, etc.

Design Guidelines
Avoid the use of unnecessary auditory icons.

Discussion

Auditory icons for weather information are not widely used, and thus may evoke different interpretations of the sounds. These inconsistencies cause the need to present the auditory icons in conjunction with other sensory information such as textual weather reports. Additionally, auditory icons convey little useful information relative to the other properties of the dissemination methods. When used in conjunction with a visual information medium, they cannot convey specific location information. It is unlikely that the auditory information would provide information beyond that which is presented visually.

Auditory icons have practical reliability disadvantages as well. When received through a PED, the device would either need to be held to the user’s (traveler’s) ear or the volume would need to be turned up for the user (traveler) to be able to hear the sound over the environmental driving noise. When the user (traveler) receives a text message, they likely are not going to put the phone up to their ear since they will be expecting to use the visual information on the phone. Additionally, some PED do not have audio capabilities, and so the information conveyed by the sound would need to be redundant with the visual information for users (travelers) who cannot receive the auditory information.

Auditory icons have been shown to decrease braking response times when presented with visual collision stimuli (1). However, weather information does not require an immediate response. Although response times were reduced, the auditory icons were shown to startle some participants and lead to inappropriate responses such as slamming on the brakes.

Auditory icons are also at risk for being perceived by drivers as a nuisance. It’s possible that travelers who see a larger map at a kiosk or on a website may not be traveling on the road for which the warning applies. The travelers who receive these warnings unnecessarily may feel that they are annoying. The perceived annoyance of auditory signals is a strong predictor of its perceived appropriateness for non-critical situations (1).

Key References

1. Campbell, J. L., Richman, J. B., Carney, C., and Lee, J. D. (2004). *In-vehicle display icons and other information elements. Volume 1: Guidelines* (Report No. FHWA-RD-03-065). McLean, VA: Federal Highway Administration. Retrieved October 6, 2009, from http://www.tfhrc.gov/safety/pubs/03065/03065.pdf.

GUIDELINE 17. DISPLAY OF TEXT PARAGRAPHS – OPEN-FORMAT

Introduction

Message presentation for text in open-format text/visual messages refers to methods used to display passages of text to maximize readability and comprehension.

Design Guidelines

Text Feature	Guidelines
Text Display	• For simple, continuous online text, display at least 4 lines at one time • If space is limited, display a few long lines of text rather than many short lines • Display text in wide columns of at least 50 characters per line • Display text in mixed case rather than all upper case • Highlight critical text, if necessary, using color or other notation rather than capitalization • Separate paragraphs by at least one blank line • Use left justification and consistent word spacing
Punctuation	• Try to avoid breaking words using hyphenation • Use conventional punctuation (i.e. periods at the end of sentences, etc.)
Sentence Phrasing	• Use clear wording and short, simple sentences • Put the main topic near the beginning of the sentence • Use distinct words (e.g. will not or not complete) rather than combined forms (e.g. won't or incomplete) • Use the active voice instead of the passive voice • Maintain the order of a sequence of events in the sentence in which they are described
Lists	• Use a single-column list when conveying a series of items • Order list items logically (order the items alphabetically if no logic exists) • Use Arabic numerals (i.e. 1, 2, 3) rather than Roman numerals (i.e. I, II, III) • If a list is too long to be displayed on one page, consider a hierarchical structure to break it into shorter lists

Discussion

Displaying 4 lines of continuous text is acceptable when the text is simple. However, if the text is complex or requires the reader to refer to previously displayed lines, more lines are necessary. Text that is displayed in wide columns is read significantly faster than text that is displayed in narrow columns. Also, text displayed in mixed upper and lower case is read more easily than text in all capital letters. If the display cannot accommodate lower case descenders, upper case should be used. If a passage of text is critical and needs to be highlighted, use color or another notation rather than capitalization to preserve legibility. It is easier for users (travelers) to read text with consistent spacing. This benefit outweighs any benefit provided by using uneven spacing to have an even right margin. Similarly, it is better to eliminate hyphenation and have a ragged right margin. To support traveler understanding, it is important to use simple wording and short sentences. Using distinct wording helps travelers understand the sense of a message, especially when it involves negation. Using separate words is not a problem for open format text messages since length is less of a concern. Additionally, it is clearer when a sequence of events (such as a diversion route) is written in the same order in which the traveler is expected to complete the actions.

When describing a series of items, users scan the items faster and more accurately when they are in a list format. Each item should start on a new line and the list should remain in a single column if space allows (except for when comparison between items makes multiple columns practical). If an entry takes up multiple lines in a list, indicate that the lines belong together using blank space between items, indenting the lines after the initial line, or marking the first line of each item using a symbol or number.

Key References

1. Smith, S.L., and Mosier, J.N. (1986). *Guidelines for designing user interface software* (Report No. ESD-TR-86-278). Bedford, MA: The Mitre Corporation. Retrieved from http://hcibib.org/sam/index.html#top on December 3, 2009.

GUIDELINE 18. DISPLAY OF SEVERE WEATHER ALERTS – SHORT TEXT/VISUAL & OPEN-FORMAT

Introduction

A severe weather alert is a warning that is essential for travelers to receive. Severe weather alerts are sometimes given unique formatting and positioning on a webpage to attract traveler attention. These recommendations are based upon the best or most common practices identified in the survey of the state weather websites in this report (see also Appendix F). This guidance does not apply to DMSs.

Design Guidelines

Guidelines	Example
• Use a bright color, such as red to draw attention • Place the alerts in a prominent location on the page • Display the alerts on a main page, not in a downloadable file or separate link • Have an assigned location for displaying alerts • Use concise wording to convey essential event information, and link to additional information as necessary	

Discussion

Of the 51 websites examined in the weather survey, 24 provided weather alerts separately from the regular weather-related information. The idea behind a weather alert is that the information is so essential to travelers that it is important that they read it. The weather alerts should be attention-grabbing. The examples above all use red text for the section headers or titles, which is a color often used to communicate hazard information (1). Each example site has a dedicated area for displaying the weather alerts, so travelers know where to expect the information to be. Additionally, the information is prominently displayed on a main page for the weather information, a place where travelers who are looking for weather information are likely to go. Due to their urgency, weather alerts should not be listed in a file that travelers must download or in a separate link. Also, alerts should be worded concisely so that they may be read quickly to obtain pertinent information. If the traveler decides that the alert applies to them, they should be able to access any additional information via a link to a separate page.

Key References

1. Campbell, J. L., Carney, C. and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (Report No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

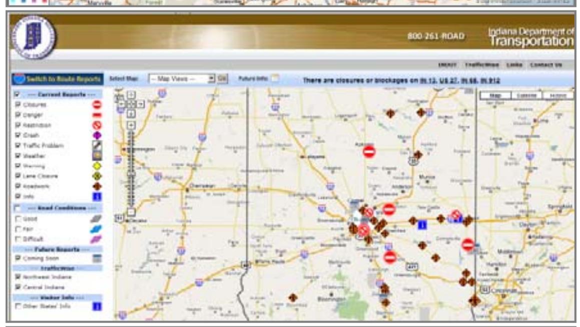
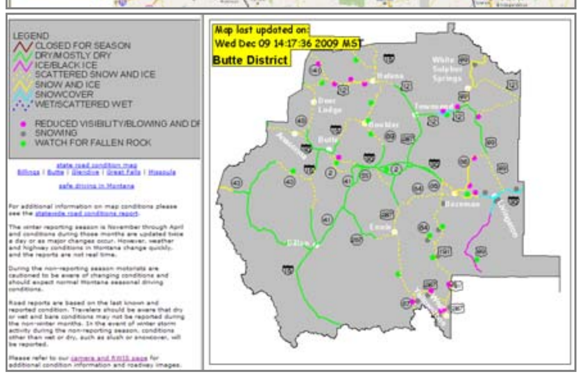
NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 19. DISPLAY OF WEATHER MAPS – OPEN-FORMAT (1)

Introduction

Of the 51 websites examined in the weather survey in this report, 45 used a map to convey some weather information. These recommendations are based upon the best or most common practices identified in the survey of the state weather websites in this report (see also Appendix F).

Design Guidelines

Guidelines	Example
• Load with a view of the entire state and allow zooming to route or street views • Icons can be used to show locations of weather-related conditions, closures, weather information sensors, etc. • Choose icons that are weather-related (commonly clouds, thunderclouds, or suns) • Many map legends allow travelers to select which events they want to view, reducing visual clutter • Color coded roadways frequently show weather-related road conditions or traffic levels (not both at the same time) • Include a timestamp to show when the map was last updated • If the map can show more than 4 or 5 weather elements at one time, use a dedicated weather map that does not show non-weather information such as traffic conditions	  

Discussion

Of the 45 websites surveyed that include weather maps, 42 load with a view of the entire state and allow travelers to zoom in to their area of interest. The maps that load with a regional view force travelers who are interested in other views to zoom out and then zoom in to another area. The icons that are weather-related are easier to associate with weather conditions, especially when a variety of information is being presented on the same map.

If there is a lot of information presented, it can help travelers reduce visual clutter if they can select the icons that they want displayed, or to have a separate weather map altogether. Color-coded roadways were used by 39 states to show road conditions or traffic levels, but travelers should not be able to select both to be shown at the same time.

Finally, a timestamp was only displayed by the map in 15 instances, however, it is important to let travelers know how current the information is. If the program crashes or freezes, an old timestamp will help preserve the credibility of a map that may be displaying out-of-date information, especially if the map states that it is "current."

GUIDELINE 20. DISPLAY OF MAP INFORMATION – OPEN-FORMAT (2)

Introduction

Message presentation for maps in open-format text/visual messages refers to the characteristics of maps that improve usability. It is useful to combine weather data with a map to show the geographic location of the events.

Design Guidelines

Map Feature	Guidelines
Orientation	• Use a consistent orientation for every map
Labels	• Label significant map features directly on the display • Position map labels in consistent locations for different features
Movement	• When a user (traveler) pans over a map to show a particular area, provide a graphic to show their position within the larger map • If using linked maps, ensure that they overlap slightly
Event Data	• Use graphic elements to display nongeographic data over a geographic area • Use additional graphic elements to indicate changes in mapped data as necessary • Provide stable map elements for changing data in automatically updated displays • If the data categories for the user's (traveler's) task cannot be predicted at a particular point, let them select the categories that they want displayed
Distance Measurements	• Provide computerized aids if distance judgments are necessary (e.g. a movable grid, concentric range rings, or a movable scaled ruler)

Discussion

Labels: The significant features on the maps should be labeled if it can be done without cluttering the display. If the labels cannot be incorporated directly onto the map, they may be shown outside of the map area and linked using a coding method. Another alternative is to allow users (travelers) to click on a geographic label and then highlight the corresponding location on the map, or vice versa. Map labels should be placed in consistent locations for similar map features (e.g. town names always directly above the town symbol).

Movement: When the map area that is displayed is larger than can fit in a frame, users (travelers) can have the option to pan the display (to move continuously over the map without any predefined boundaries), or click links to predefined areas. If the users (travelers) can pan the display, they should be provided with a graphic (i.e. a miniature display of the entire map in a corner of the display and a rectangle imposed on top) to show the area that they are viewing. This helps the user (traveler) stay oriented within the entire display and provides information as to which direction to move in order to see another section. If the users (travelers) are provided with links to different map sections, it is important that the sections provide some overlap with each other in case the area that the user (traveler) wants to see is at a boundary between sections.

Event data: If nongeographic data is being displayed over a geographic area (such as the amount of rainfall in different regions), it is easier to visually compare the values if they are coded using graphic elements than alphanumeric characters. Alphanumeric characters may also add visual clutter with the existing map labels. If changes in data, such as weather front movements, are to be shown on a static display, additional graphic elements are needed to show directional movement. These can include arrows, or directional "pips" added to contour lines. It is sometimes recommended that "pips" be 1-2 times as large as the alphanumeric characters and spaced at 5-10 times their width. If the data are changing and the displays are automatically updated, some stable elements are needed as a frame of reference. These elements can include coordinates or geographic elements. If the changing elements cover background elements, the background should return when the changing data moves away. If the data that the traveler will want to display cannot be predicted, let travelers select the categories that will be displayed. Travelers should be given a reminder of available categories and be able to easily select them. However, this does introduce the risk that travelers will select too many or incorrect categories, making their task more difficult.

Key References

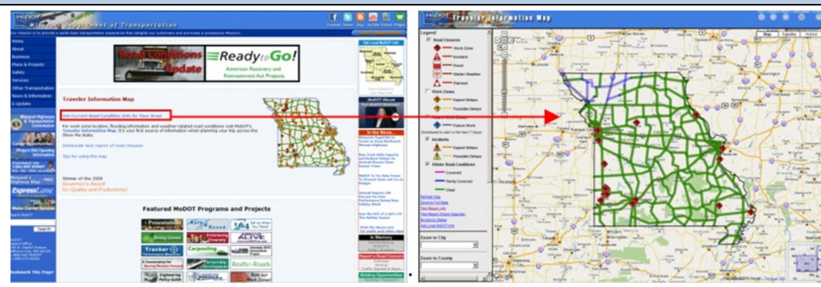
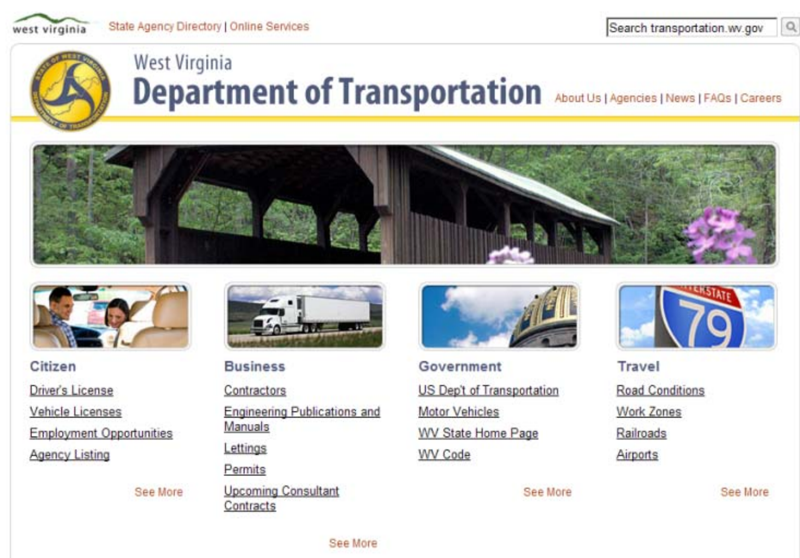
1. Smith, S.L., and Mosier, J.N. (1986). *Guidelines for designing user interface software*. (Report No. ESD-TR-86-278). Bedford, MA: The Mitre Corporation. Retrieved from http://hcibib.org/sam/index.html#top on December 3, 2009.

GUIDELINE 21. LINKING TO WEATHER INFORMATION – OPEN-FORMAT

Introduction

Linking to weather information refers to the internal and external links that are provided on the homepage through which travelers can access the weather information. These recommendations are based upon the best or most common practices identified in the survey of the state weather websites in this report (see also Appendix F).

Design Guidelines

Guidelines	Example
• Link to the weather information directly from the DOT homepage • Use a single link rather than a string of links • Maintain the functionality of the links	
• Choose link titles that are associated with road condition information (e.g. “road conditions” or “traveler information”)	

Discussion

A main goal of linking to weather information directly from the homepage is to reduce the *information access cost*. The information access cost is defined by the number of pages and links that the traveler must search through to find the information that they need. Travelers save time if they can find the information with one click, using a single link rather than a string of multiple links. Multiple homepage links that lead to the same page should be avoided since they only increase the visual clutter on the page. Additionally, the links should be functional and lead to the information that the traveler expects. Link titles such as “road conditions” or “traveler information” are more likely to be associated with weather information than “highways” or “miscellaneous.”

GUIDELINE 22. TRAFFIC CAMERA DISPLAYS – OPEN-FORMAT

Introduction

Live cameras or periodically updated static images are used on 41 of the 51 weather websites surveyed to show traffic congestion levels and road conditions. These recommendations are based upon the best or most common practices identified in the survey of the state weather websites in this report (see also Appendix F).

Design Guidelines

<table>
<tr><th>Guidelines</th><th>Example</th></tr>
<tr><td>Provide a timestamp to show how current the picture is
Provide an indication of how often the video updates if the feed is not continuously streaming</td><td></td></tr>
<tr><td>Consider allowing users (travelers) to pause the video if appropriate</td><td></td></tr>
<tr><td>Provide precise location information including the direction that the traffic on the camera (or nearest the camera) is flowing
Show the roadway so that users (travelers) can get an idea of the pavement and traffic conditions</td><td></td></tr>
</table>

Discussion

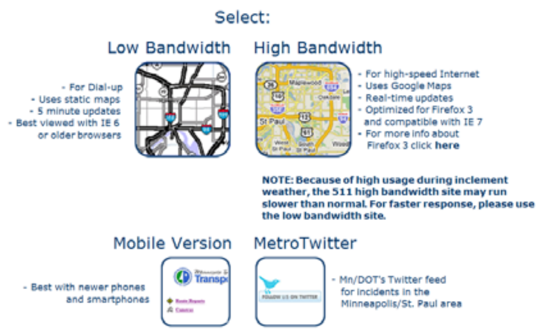
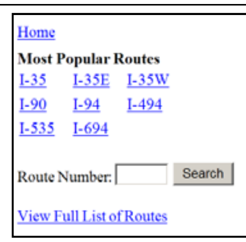
Camera images are generally presented in a separate window, sidebar, or pop-out from the map display. Live cameras either update continuously or at discrete intervals. The majority (34 out of 41) of the websites surveyed that included a camera display also provided a timestamp for their camera information. It is very important that the date and time are prominently displayed on or near the picture so that the traveler knows if the information is current. If the camera breaks or freezes, the date and time will inform the traveler that the picture is old, preserving credibility. If the picture is updated at discrete times, an indication of how often the picture is updated prevents travelers from checking back too often and perhaps becoming frustrated. For continuously updating camera feeds, a consideration should be allowing the traveler to pause the camera. This may help travelers whose systems run slowly. Additionally, if travelers are looking closely at the image to see details, it will be easier for them to focus if the picture isn't constantly updating. Precise camera location information including direction is provided by 26 out of 41 websites. Even if landmarks are visible in the frame, at nighttime it may be difficult to tell which direction the camera is facing and which road it is on. The direction that the camera is facing is provided through comparative directional photographs (3 websites), or an explicit statement of the side of the road where the camera is located (23 websites). Providing directional information is especially critical for pan-tilt-zoom cameras which change shooting directions. Also, the roadway should be prominently shown in the frame so that travelers can see what the pavement and traffic conditions are like.

GUIDELINE 23. ACCOMMODATING OTHER WEB-BASED DISSEMINATION METHODS – SHORT TEXT/VISUAL & OPEN-FORMAT

Introduction

Travelers may use portable electronic devices to access internet weather websites. There are multiple ways in which these websites can support access from portable devices with smaller screens. These recommendations are based upon the best or most common practices identified in the survey of the state weather websites in this report (see also Appendix F).

Design Guidelines

Guidelines	Example
• Provide a way for users (travelers) to select an appropriate version for their device	
• Provide a short, text-only version for devices with smaller screens	
• Support subscriptions to weather alerts for PEDs	

Discussion

Only 12 out of 51 websites surveyed support portable electronic devices such as cell phones. Although many of these devices can load the same websites as computers, due to their screen size and bandwidth limitations, it is impractical to do so. Loading weather sites with lots of content and maps takes a lot of bandwidth for a smaller device and may take a long time. By providing a way for travelers to select their version, the content of the site can be tailored to their needs.

On devices with smaller screens, viewing detail on a map is impractical. By providing a text-only version with short text, travelers can avoid awkward text wrapping, slow-loading maps, and the complex navigation of much larger sites. A few sites also supported subscriptions for weather alerts to be sent to PEDs.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 24. USE OF TABLE INFORMATION – OPEN-FORMAT

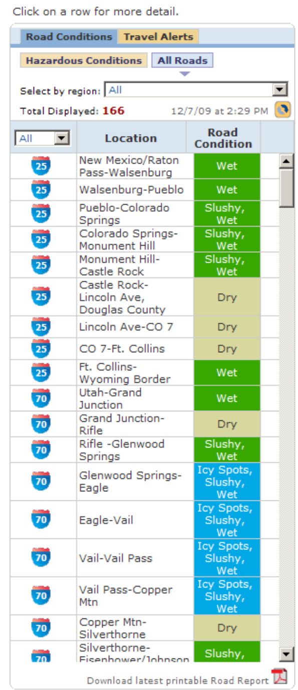
Introduction

The presentation of weather information refers to the tables or lists used to present mostly textual road condition information. On 34 of the 51 weather sites surveyed in this report, textual road condition information was presented in addition to a visual representation on a map. These recommendations are based upon the best or most common practices identified in the survey of the state weather websites in this report (see also Appendix F).

Design Guidelines

<table>
<tr><th>Guidelines</th><th>Example</th></tr>
<tr><td>

- Order list/table items alphabetically or numerically
- Provide a sort feature to allow travelers to find the information by route or region
- If displaying a lot of text for many locations, display the short form by default and allow travelers to click for more information
- Use multiple columns to display different types of information rather than multiple lines within the same row
- Provide a time-stamp

</td><td>


</td></tr>
</table>

Discussion

When presenting a list or table of weather information, the elements should be ordered in a way that will be easily understood by the travelers. The most common ways of accomplishing this are either alphabetical or numerical ordering by the first column. If information is being presented for an entire state, let the travelers narrow down which entries are displayed by selecting a route or region of interest. Most commonly, websites allowed travelers to select a route name or area of the map for which they wanted a listing of the weather information. If long text fields such as weather reports are going to be displayed, reduce the field to a shorter form (such as the road condition fields above) and allow travelers to click if they want more information. Organize the information in multiple columns, rather than multiple lines in a single row, to allow travelers to scan the first column for the information that they need.

GUIDELINE 25. COMMUNICATING TIMEFRAME – SHORT TEXT/VISUAL & OPEN-FORMAT

Introduction

A timeframe is sometimes given in a message to convey the length of a delay or a travel time.

Design Guidelines

Type of Information		Guidelines
Date Information	Dates in the next week	• Use days of the week rather than calendar dates (e.g. Tue – Thur) • Do not use the phrase “For 1 Week” because the start and end dates are ambiguous • “Nite” may be used in place of “Night” • A hyphen with a space on either side may be used in place of “thru” • “Weekend” may be used if the event begins on Saturday morning and ends on Sunday evening
	Dates not in the next week	• Use a 3-letter month abbreviation rather than a numerical month representation (i.e. Apr 21 rather than 4/21) • Only state the month once if both dates in a range are in the same month (i.e. Apr 21 – 23 rather than Apr 21 – Apr 23) • Don’t include day, date, AND time information
Time Information	Travel times	• Travel times can be displayed in multiple formats: “# MIN AT 8:20”, “#-## MINUTES”
	Delay times	• Delay times should be relative to the drivers’ normal travel times

Discussion

Research has shown that drivers have difficulty converting calendar dates to appropriate days of the week (1). However, it is often desirable to present closure or other information more than one week in advance, necessitating the inclusion of numeric date information in the message. In a laptop study examining date formats, Ullman, Ullman, and Dudek (2) found that regardless of the format that was used to present the day and date information, only approximately 75% of drivers could tell if the event would impact their current or future travel.

Dudek (1) found that displaying recent historic travel times is not a significant issue if differences in the expected and actual times are not significant. In a study of travel time phrasing, he also found that two different signs: “TRAVEL TIME TO DOWNTOWN 20 MINUTES” and “TRAVEL TIME TO DOWNTOWN AT 7:20 A.M. 20 MINUTES” caused no significantly different time expectations for drivers. Also, only 10% of drivers expected their travel time to be exactly 20 minutes.

Credibility is a major factor when providing travel times. Travel times are easy for drivers to verify when they reach their destination, potentially proving the message to be incorrect. When travel times cannot be predicted and historical travel times are used, it should be ensured that they are reasonably accurate. Additionally, a couple of TMCs in Texas are using the formats presented above to convey the time that the travel time was estimated or ranges of times in an attempt to increase credibility.

Key References

1. Dudek, C. L. (2004). *Changeable message sign operation and messaging handbook* (Report No. FHWA-OP-03-070). College Station, TX: Texas Transportation Institute.
2. Ullman, G.L., Ullman, B.R., and Dudek, C.L. (2007). Evaluation of alternative dates for advance notification on portable changeable message signs in work zones. *Transportation Research Record, 2015*, 36-40.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 26. COMMUNICATING TIMEFRAME – AUDITORY

Introduction

A timeframe is sometimes given in a message to convey the length of a delay or a travel time. Time-stamps on auditory messages inform the driver how current the information is.

Design Guidelines

- Time-stamps
  - Providing a time-stamp for current information lets drivers know when it was entered into the system
  - Providing a time-stamp for long-term information can confuse drivers
  - The time-stamp should use the time that the message was updated, not the time that the incident occurred
- Travel time information can be presented in two ways:
  - Absolute time: “segment travel time is 24 minutes”
  - Should never be less than the travel time at the speed limit
  - Multi-segment or corridor travel times are acceptable in urban areas
  - Delay beyond normal conditions: “segment travel time is delayed 5 minutes”

Discussion

Providing time and/or date information gives drivers a sense of the accuracy and reliability of the information (1). However, if a time-stamp is given for an event that is long-term and not changing, an old time-stamp may give the impression that the information is out of date and inaccurate even if it is not. Thus, it is important that time-stamps remain current, especially if the information is presented for a longer period of time. The time-stamp should use the time that the message was updated so that drivers will know how current the information is and if the incident is likely still ongoing.

Travel time information can be useful if an estimate can be made with reasonable accuracy. The travel time can be presented as an absolute travel time or a delay time. If it is presented as a delay, the time given should be the amount of time that is expected to be spent beyond the normal travel time.

Credibility is a major factor when providing travel times. Travel times are easy for drivers to verify when they reach their destination, potentially proving the message to be incorrect. When travel times cannot be predicted and historical travel times are used, it should be ensured that they are reasonably accurate. Additionally, a couple of TMCs in Texas are using the formats presented above to convey the time that the travel time was estimated or ranges of times in an attempt to increase credibility.

Key References

1. 511 Deployment Coalition. (2005). *Implementation and operational guidelines for 511 services* (Version 3.0). Retrieved November 30, 2009 from http://ops.fhwa.dot.gov/511/resources/publications/511guide_ver3/511guid3.pdf.

GUIDELINE 27. COMMUNICATING GEOGRAPHIC EXTENT – SHORT TEXT/VISUAL

Introduction

Geographic extent refers to the area affected by a weather event.

Design Guidelines

Road Density	Type of drivers	How to reference
Cross-roads are close together	Drivers familiar with the area	By street names, exit names, exit numbers, or landmarks
	Drivers unfamiliar with the area	By distance from the DMS or exit numbers
Cross-roads are far apart (e.g. rural areas)	All drivers	By distance from the DMS

Examples of Geographic Descriptors	
Common descriptors used by TMCs	• 1 MILE • # MILES • AT [highway name, exit ramp number, etc.] • NEAR [highway name, exit ramp number, etc.]
Other descriptors to consider	• BEFORE [highway name, exit ramp number, etc.] • PAST [highway name, exit ramp number, etc.]

Discussion

The reference points used to convey geographic information should vary by the density of the cross-roads and the familiarity of the drivers with the area. If the cross-roads are close together, drivers will be able to use the road names, exit names, exit numbers, or landmarks to understand geographic areas. If the drivers are unfamiliar with the area, the road names and landmarks will likely be unfamiliar and thus will provide no useful information. The distance from the DMS or exit numbers can be easily understood in reference to their current position. If the cross-roads are far apart, providing road names may not provide sufficient granularity for weather locations. The distance from the DMS provides drivers with precise location information with a reference to their current location. However, if the message is read from a PED instead of a DMS, reference points such as street names, exit names, exit numbers, or landmarks will need to be used since the traveler's exact location will not be known.

Key References

1. Dudek, C. L. (2004). *Changeable message sign operation and messaging handbook.* (Report No. FHWA-OP-03-070). College Station, TX: Texas Transportation Institute.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 28. COMMUNICATING GEOGRAPHIC EXTENT – AUDITORY

Introduction

Geographic extent refers to the area affected by a weather event. The information may be relevant for an entire region, or only a specific route.

Design Guidelines
• Weather information should be presented with a navigation reference such as (1): o Road segments o Cities / towns o Mileposts o Exits o Major intersections / interchanges o Landmarks o Rest areas

Discussion

The 511 Guidelines present little discussion related to the guideline presented above. It is important to provide a known, stationary reference for the weather information since listeners will be in a variety of geographic locations. Providing a geographic reference lets listeners know if the weather will affect their travels and provides additional information as to how to avoid the weather if necessary. When providing weather information, the navigation references should use the wording that is commonly available to drivers on roadway signs. If the official name or mapped name is provided, many drivers will likely not know the location and the information will not be useful.

Key References

1. 511 Deployment Coalition. (2005). *Implementation and operational guidelines for 511 services* (Version 3.0). Retrieved November 30, 2009 from http://ops.fhwa.dot.gov/511/resources/publications/511guide_ver3/511guid3.pdf.

GUIDELINE 29. COMMUNICATING DEGREE OF URGENCY – SHORT TEXT/VISUAL, OPEN-FORMAT & AUDITORY

Introduction

Communicating the degree of urgency in a road weather message refers to general design principles and specific message content that communicate the priority, timing, and driving impacts of weather events.

Design Guidelines

The Guidelines below provide both general principles for communicating the degree of urgency as well as principles that are specific to the three classes of dissemination methods identified in these guidelines (short text/visual, open-format text/visual, and auditory).

Road Weather Message Characteristic	Guidelines
Words/text	• Words that communicate moderate urgency include caution, warning, or hazard. • Words that communicate high urgency include: severe, emergency, life-threatening, deadly.
Colors	• Use green to communicate clear or normal conditions/routes (low urgency). • Use yellow to communicate caution, warning, slow moving areas of traffic or roadway locations moderately compromised by weather events (medium urgency). • Use red to communicate danger, emergencies, extremely slow traffic conditions, or roadway locations either made impassable or highly dangerous due to weather events (high urgency).
To increase the perceived urgency of an icon or symbol (Campbell, Richman, Carney, & Lee (1)):	• Increase font size of text labels to identify icons of greater urgency. • Increase white space around text labels. • Use red lettering or red background. • Increase line weight of the icon's border. • Increase relative size of the high urgency icon. • Pair with an auditory cue. • Show the consequence of not responding appropriately. • Do not use blue or green coloration, as those convey low urgency.

Specific Guidelines for *Short Text/Visual* Dissemination Methods
• Use **command** style messages when the situation is urgent and an immediate control action is required by the driver. Whenever an immediate control action is not required, or the situation is not urgent, a **notification** style message may be used (2). • From Campbell, Carney, and Kantowitz (2), "message style" refers to the use of command vs. notification style messages. Examples of command style messages include: "slow down" or "move to the right lane" Examples of notification style messages include "ice ahead" "use alternate route", or "storm warning".

Design Guidelines

Specific Guidelines for *Open-format Text/Visual* Dissemination Methods
• From Campbell, Carney, and Kantowitz (2), when presenting messages that do not require immediate action (low urgency): o Present the information in the order of importance or relevance to the driver o Present the most important information at either the beginning or the end of the message because it is easiest to recall • When presenting urgent information: o Use the auditory modality when possible; for lower priority messages, the visual modality can be used (2). • When providing information through menus: o Provide a means for users (travelers) to "go back" into the menu structure and repeat or retrieve urgent information (3)

Specific Guidelines for *Auditory* Dissemination Methods
• Present the most important/urgent information at either the beginning or end of the message in order to improve driver recall of the message (2). • Provide a means for repeating urgent message—this is especially helpful for older drivers (2). • When providing "time-stamps", the time data should reflect the time that the information was updated, not the time that the incident occurred (3).

Discussion

Communicating the appropriate degree of urgency to travelers is important because travelers use the cues to urgency that are contained within a message to make travel decisions regarding if they should travel, when they should travel, if a mode choice is in order, or if a planned route should be changed. Urgency can be communicated in numerous ways, including words, phrases, colors, location on a visual display, location within a message, and the modality used to present the message. Importantly, the many different aspects of a particular weather message dissemination method (i.e., DMS vs. website vs. 511) can be used together to effectively communicate the appropriate degree of urgency to travelers.

The priority of a message is a function of how quickly a response must be made by the driver, as well as the consequences of failing to make the proper response (2). A high-priority message requires a fast response (0-5 minutes) and has serious consequences, such as a crash with possible injuries or fatalities. For example, a weather-related roadway condition—such as an upcoming road that is washed-out due to a flash flood. A lower priority message has no response needed for at least 5 minutes and has no immediate consequences. An example of a lower priority message is a forecast for rain on the next day.

Key References

1. Campbell, J. L., Richman, J.B., Carney, C., and Lee, J.D. (2004). *In-vehicle display icons and other information elements. Volume I: Guidelines* (FHWA-RD-03-065). McLean, VA: Federal Highway Administration (see also http://www.tfhrc.gov/safety/pubs/03065/index.htm).
2. Campbell, J. L., Carney, C., and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (FHWA-RD-98-057). Washington, DC: Federal Highway Administration.
3. 511 Deployment Coalition. (2005). *Implementation and operational guidelines for 511 services (Version 3.0)*. Retrieved November 30, 2009 from http://ops.fhwa.dot.gov/511/resources/publications/511guide_ver3/511guid3.pdf.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

GUIDELINE 30. COMMUNICATING DEGREE OF CERTAINTY – SHORT TEXT/VISUAL, OPEN-FORMAT & AUDITORY

Introduction

Communicating the degree of certainty in a road weather message refers to general design principles and specific message content that communicate the likelihood of road weather events predictions and the impacts of these events to travelers. The Guidelines below should be used to communicate the degree of certainty in road weather messages.

Design Guidelines

Ways to communicate the degree of certainty:

- Provide a percentage (e.g., 30%, 50% 100%) corresponding to the likelihood of a road weather event.
- Provide a qualitative description (e.g., "certain", "possible", "a chance") corresponding to the likelihood of a road weather event.
- Provide additional details about the weather event—or its driving impact—to improve the specificity of the prediction and increase the certainty communicated by the message. These details can include information about the location, timing, or impacts of a road weather event.

The value of road weather information is only as great as the trust that a traveler can place in the accuracy of the information. Goals for the accuracy of road weather information (adapted from Kantowitz, Hanowski, & Kantowitz, 1):

- Across a typical trip, road weather information should be at least 70% accurate.
- Higher accuracy levels may be required by drivers in a familiar setting (e.g., residents of a city) than in an unfamiliar setting (e.g., rental car drivers).
- 100% accuracy yields the best driver performance, but information above 71% accuracy should yield acceptable levels of trust.

Discussion

Communicating the appropriate degree of certainty about road weather messages to travelers is important because travelers use the "cues to certainty" that are contained within a message to make travel decisions such as: if they should travel, when they should travel, if a mode choice change is in order, or if a planned route should be changed. As seen above, certainty can be communicated in numerous ways, including the likelihood of an event, as well as the specificity with which a road weather event or driving impact is communicated.

In this regard, "specificity" can refer to:

- Where a road weather event will occur or impact driving (specificity of location)
- When the road weather event or driving impact will occur (specificity of timing)
- The consequences of a road weather event on driving conditions (specificity of impacts)
- Secondary impacts of a road weather event, such as power outages, school closures, etc.

A key concept related to certainty is the *accuracy* of information presented to travelers. Accuracy was a key topic in Campbell et al. (2), who noted: *"accuracy refers to the correctness, usually expressed as a percentage, of traffic information presented to motorists. In this context, accuracy is considered to be a binary concept; i.e., the information is either accurate or inaccurate. Although accuracy is most often discussed with respect to congestion levels associated with various routing options, it may also refer to total travel time estimates, estimates of time delays due to congestion, and presentation of accident information."* This is equally true of road weather information: accuracy leads to credibility, credibility leads to trust, and trusted information in more likely to used by travelers than information that is *not* trusted. Thus, information that is more accurate is simply more valuable to travelers.

The accuracy of road weather messages contribute to travelers' sense of the certainty of messages in two ways: 1) their willingness to trust a specific message when making travel decisions at a given point in time (short-term trust) and 2) their confidence in road weather messages over time (long-term trust).

The goal of 70% accuracy in the guidelines above was adapted from a study that measured driver's trust in a simulated in-vehicle Advanced Traveler Information System (ATIS) at different levels of system accuracy. Results showed that while 100 percent accurate information yields the best driver performance and subjective ratings of the system's usefulness, information that was 71 percent accurate remained both acceptable and useful. Drivers seem willing to tolerate some error in the information provided to them. However—at least in the ATIS study—when information accuracy drops to 43 percent, driver performance and opinion suffer. Thus, information accuracy below 71 percent is not recommended to system designers. Similar impacts on driver attitudes about inaccurate presentation of hazard information were found by Jonsson, Nass, Harris, and Takayama (4).

Dudek (3) also stresses the importance of displaying accurate information to travelers. He further states that if messages are not trusted by travelers, eventually they will be ignored. If travelers ignore the messages, any advantages that would have been provided by the messages are negated. Dudek (3) also lists eight major reasons why DMS message credibility suffers:

- Information is inaccurate
- Information is not current
- Information is irrelevant to most travelers
- Information is obvious, and thus redundant to travelers' visual inspection
- Information is repetitive, i.e., the same information is presented over a long period of time
- Information is trivial with regard to the driving task
- Information is erroneous and can be easily checked by travelers and disproved
- Information is poorly presented and thus difficult to comprehend or confusing

Although these eight reasons are provided by Dudek (3) specifically in reference to DMS signs, they likely apply to all dissemination methods.

One issue to consider when presenting road weather information to travelers is that there may be trade-offs between the accuracy of the messages provided to travelers and the timeliness of such information. For example, information accuracy may be increased by using multiple, independent sources of raw weather data to derive predictions of the likelihood of a weather event or of weather-related impact on driving. However, such increases in accuracy may increase the time between the onset of the weather event, and the presentation of relevant messages through a given dissemination method.

Key References

1. Kantowitz, B. H., Hanowski, R. J., and Kantowitz, S. C. (1996). *Development of human factors guidelines for advanced traveler information systems and commercial vehicle operations: The effects of inaccurate traffic information on driver acceptance of in-vehicle information systems* (FHWA-RD-96-145). Washington, DC: Federal Highway Administration.
2. Campbell, J. L., Carney, C., and Kantowitz, B. H. (1998). *Human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO)* (FHWA-RD-98-057). Washington, DC: Federal Highway Administration.
3. Dudek, C. L. (2004). *Changeable message sign operation and messaging handbook.* (Report No. FHWA-OP-03-070). College Station: Texas Transportation Institute.
4. Jonsson, M., Nass, C., Harris, H., and Takayama, L. (2005). Influence of hazard system accuracy on driving performance. Proceedings of the 12th World Congress on Intelligent Transport Systems.

NOTE: The use of Portable Electronic Devices, such as cell phones, while driving is a distraction. Consult the caveat on page 98 for more information.

CHAPTER 6. IDENTIFCATION OF IMPLEMENTATION AND EVALUATION STRATEGIES

Overview

As demonstrated by past efforts by Battelle to develop human factors design information (see Campbell, Richard, & Graham, 2008; Campbell, Brown, Richard, & Graham, 2008, as well as Campbell, 1995, 1996) Battelle's general philosophy and our technical activities associated with human factors guidelines is focused on producing effective guidelines that have high actual and perceived value to the intended end-user design community. A key to increasing the value of human factors information intended for use by non-human factors end-users is to both carefully implement the guidelines and then rigorously evaluate the utility from the perspective of these end-users. Below, we discuss the anticipated research results and our implementation and evaluation plan for this project with respect to several key elements, including:

- Key products expected from this research.
- Potential audience and market.
- Potential impediments to successful implementation.
- Key activities required for successful implementation.
- Criteria for judging the progress and consequences of implementation.

Key Products Expected from this Research

The final results from this project will be documented in a final report with a stand-alone executive summary. The following are important products expected from the research:

- A set of recommended improvements and guidelines for road weather information communication and presentation that meets the needs of the drivers and travelers for different weather conditions and travel scenarios (Chapter 5).
- A technical paper suitable for publication, with abstract (provided separately from the current report).
- A presentation suitable for a professional/technical conference or meeting related to this project (provided separately from the current report).
- A two-page flyer describing the study (provided separately from the current report).

Potential Audience and Market

The above research results will provide clear, relevant, and easy-to-use improvements and guidelines for road weather information communication and presentation that meets the needs of the drivers and travelers for different weather conditions and travel scenarios. Potential audiences and markets for the products generated in this research include:

1. State and local DOT personnel responsible for the development and dissemination of road weather advisory and control messages,

2. FHWA staff responsible for coordinating and implementing national efforts to improve the value and timeliness of road weather messages,
3. The broader transportation research community (which would include state and local DOT personnel and FHWA staff) who can use the results from this project to identify key research gaps, and
4. Developers of devices (e.g., changeable message sign (CMS), DMS, PEDs, websites, etc.) used to disseminate road weather information to travelers.

This last group represents an unconventional, yet potentially fruitful extension of the end-user community. In particular, given that mobile technologies are an emerging area, in addition to one that is already covered at a relatively detailed level in the current guidelines, targeting device manufacturers provides a complementary avenue for improving the dissemination of road weather information to travelers. More specifically, one challenge that road weather message designers face when developing messages for mobile devices is how a message will actually appear to travelers using these devices. In particular, there is a risk that the effectiveness of a well-design road weather message could be undermined by hardware limitations of a mobile device. By including the developers and manufactures of these devices in the targeted end-user community, there is an opportunity to: 1) incorporate consideration of inherent technological constraints into the design guidelines, and 2) raise awareness about road weather message presentation requirements among manufacturers to facilitate better compatibility between messages and the devices used to communicate that information. This represents a more comprehensive and forward-looking approach to communicating road weather information, and would require additional effort and resources, however, the potential payoff in terms of synergies gained by promoting hardware capabilities that complement improvements in message design make this worth considering.

Potential Impediments to Successful Implementation

We believe that there are three potential impediments to moving the results of this research into practice in the real world: 1) limited availability of the recommendations and guidelines, 2) a lack of perceived value, and 3) lack of involvement from end-users. Each of these impediments, and some ideas for how to address them, is discussed below.

- **Limited availability of the guidelines:** Clearly, in order to be used in practice, the materials from this effort must be made readily available to potential end-users, and in as many forms as economically feasible. Potential end-users need to be both aware of the existence of the materials and be given access to them in a form that is consistent with their organizational and daily work practices. Communicating the availability of the materials, as well as the content of the materials, and the methods used to develop them, will be crucial to “spreading the word” about the results of this project. However, making the recommendations and guidelines available in both hardcopy and a full media format as soon as possible is also critical. For the ATIS/CVO guidelines produced for the FHWA, in the 1990’s, the costs associated with making hardcopy versions of the guidelines limited production to 500 or so copies, which were quickly disseminated. Real “saturation” within the ATIS/CVO design community was achieved only when the web-based version of the guidelines was made available to everyone. The rapid transition from hardcopy to electronic form for the ATIS/CVO project can serve as a useful model for the current effort. Also, future outreach activities can also serve to inform end-users about the availability of the materials and to involve end-users in the development/evaluation process.

- **Lack of perceived value:** State and DOT staffs that are responsible for disseminating road weather messages to travelers have a number of related documents and procedures available to them, and unless they perceive the material produced by this project to contain *uniquely* valuable, useful information, it may not be used on a regular basis. Indeed, this exact problem is what has plagued the vast majority of human factors guidelines intended for use by non-human factors practitioners. For the current project, this underscores the need to develop the guidelines with end-user needs and requirements firmly in mind, and to develop a set of recommendations and guidelines source that complement existing documents and procedures. We believe that an outreach effort may help increase perceived value, and that perceived value should be a key evaluation topic in the future.
- **Lack of involvement from end-users:** Human factors recommendations and guidelines generally benefit from end-user involvement during their development. Such involvement can include providing a better understanding of operations and procedures in state and local DOTs, providing documents and other source materials to the guideline-development team, involvement in public workshops and seminars that feature and use the guidelines, and participating in on-going evaluations of the guidelines' usefulness. In the current project, end-user involvement was limited to the activities described in Chapter 2, in which the team learned more about current practices in a number of state DOTs. An important activity in the future will be to work closely with a number of state and local DOTs to review the products from this project, evaluate their usefulness and how they could be improved to better-meet the needs of end-users, and to then revise the current recommendations and guidelines accordingly. We discuss this activity in more detail below under *"Test and Evaluation Effort"*.

Key Activities Required for Successful Implementation

There are a number of specific activities that will be crucial to successful implementation of the research products from this project, they include:

- Make results available as early as possible. End-users can't use information that they don't have or don't know about. As soon as practical and possible, hardcopy and electronic formats of the recommendations and guidelines from this project should be made available and disseminated to the road weather message community.
- Evaluate and revise the current recommendations and guidelines. As noted above, end-user involvement in the development of the recommendations and guidelines for road weather messages has been minimal. The current materials should be evaluated by a representative set of end-users and revised (to the extent possible) to reflect their assessments. In the past, we have seen that such evaluations result in a much-improved set of guidelines. We discuss this activity in more detail below under *"Test and Evaluation Effort."*
- Conducting a series of outreach activities will serve to both: inform end-users about the existence of the human factors guidelines for road weather messages and help the FHWA

to improve them. In the past, we have found that outreach activities are crucial for developing and maintaining an active “end-user base” with a vested interest in continuously improving these materials and in “getting the word out” to like-minded colleagues. We discuss this activity in more detail below under *“Outreach Effort.”*

Criteria for Judging the Progress and Consequences of Implementation

The findings and activities of this research project could provide a number of opportunities for tangible and measurable improvements in the human factors aspects of road weather messages and dissemination methods. Following the successful completion of this project, the progress and consequences could be judged by the following criteria:

- Evaluation of the recommendations and guidelines by the end-user community. Since the primary results from this project have an intended use and an intended target audience, perceptions, case studies, and feedback from the end-user community will be key to determining whether or not the effort is a success. End-user evaluations on the overall value of the guidelines, the value of individual guidelines, the format used to present the human factors information, and feedback on where and how often the products from this research have been used, will provide useful information on the progress and consequences of implementation.
- Objective indices of interest and application. Depending on how the “products” from this effort are disseminated, objective measures of dissemination can be used to assess the effectiveness and value of the human factors recommendations and guidelines. Specifically, the number and nature (domain, connect time, content viewed) of web site “hits”, CD-ROM requests, workshop/lecture attendance, hardcopy requests can be used to assess interest in and application of the products from this effort.
- State-level application of the recommendations and guidelines. The results from this research provide limited benefits if not applied at the state level, given the states’ responsibilities for disseminating road weather messages. Following completion of the project, its success could hinge on the number of states actively using the guidelines from this effort to select dissemination methods and design road weather messages.
- “Promotion” of the recommendations and guidelines. Clear indications of the quality, applicability, and value of the materials developed in this project will be if the recommendations and guidelines are—in one form or another—adopted for use by American Association of State Highway and Transportation Officials (AASHTO), or otherwise “promoted” to a recommended practice or design standard.

Test and Evaluation Effort

Some key aspects of this implementation and evaluation plan can be undertaken immediately. In particular, we believe that a Test and Evaluation Effort for the Weather Message Guidelines can be conducted over the next 12 months. We have conducted many such evaluations of our guidelines in the past and are confident that such an evaluation is both feasible and valuable. A key risk to an evaluation of this type is in making sure that the “end-users” included in the evaluation are both representative of the broader population of end-users and committed to providing timely and helpful feedback to the effort. Twelve state DOTs participated in the current project activities described in Chapter 2. This group, as well as others that could be suggested by the FHWA could likely serve as participants in this evaluation. The test and evaluation effort should consist of the following tasks:

Prepare for Evaluation of the Weather Message Guidelines

- Contact state DOTs and individual TMCs and identify agencies that are willing to review and evaluate the Weather Message Guidelines. Approximately 12 state DOTs participated in the current project; the points-of-contact from this effort would be a good starting point to begin recruiting for the evaluation effort. Participants in the evaluation could also include members of the road weather service provider community.
- Augment the current Weather Message Guidelines with introductory and supporting materials that provide more detail regarding the purpose of the guidelines, how they could be used, and the organization/format of the guidelines. Specifically, this could include:
    - An introductory chapter that describes the objectives of the document and provides a rational for using a systematic process for designing road weather messages, including using the guidelines.
    - A chapter that discusses the format and layout of the design information. This includes descriptions of the format of individual guidelines, in addition to the overall organization of the guidelines and supporting material.
    - Basic index/glossary.
    - A related activity would be to reorganize the current guideline content (e.g., move guideline topics to a more prominent position). This involves re-evaluating the current organization and determining what is the best way to order the design information in the context of the broader document, and with the additional material added.
- Develop both on-line surveys that could be completed by individuals, as well as structured response booklets that would serve as a means to guide discussions and record responses for in-person discussions at state DOTs and individual TMCs. In addition, it might be necessary to develop a mini-tutorial with examples on how to use the guidelines, so that interviewees can familiarize themselves with the guideline materials prior to the interview. These mini-tutorials would make the interviews significantly more productive, since less time would be required to describe the basic elements of the documents, and end-users would have a chance to identify shortcomings or improvements they would like see, prior to the interview.
- In addition, the value and utility of weather messages and the recommendations for dissemination methods should be tested on a small number of travelers—perhaps in 4-6 focus groups or an in-person traveler survey similar to the one described in Chapter 4. In this task, the nature of these groups would be determined, the focus groups planned, participants recruited, and Moderator Guides developed. Although this is more of a supplementary activity for guideline implementation, it can result in more relevant and specific design information for certain topics. There are special considerations associated with this type of data collection, and they are addressed separately below.

Conduct Evaluation of the Weather Message Guidelines

- Distribute the Weather Message Guidelines to the state DOTs and individual TMCs participating in the evaluation. For the state DOTs and individual TMCs, the evaluation would focus on whether the guidelines are seen as appropriate, applicable, and valuable to day-to-day operations. A particular focus should be on how the content, format, or organization of the guidelines could be changed to better meet the needs of these end-users. For example, does the inclusion of the traveler information needs design tool contribute to the value of the guidelines or does it unnecessarily complicate their use? Are there other relevant design topics for which recommendations/guidelines are needed? How well does the document meet their day-to-day needs? How should the guidelines be revised to better reflect differences across state DOTs or TMCs with respect to how road weather messages are constructed and disseminated (e.g., the use of a standard set of DMS messages vs. messages created as needed). Do any of the recommendations/guidelines conflict with their current practices—if so, where and how? In what form should be final guidelines be produced (e.g., .doc, .pdf, .html, all of the above?)?
- For the individual travelers, focus groups of 8-10 travelers (e.g., younger, older, commercial travelers) could be asked about their general use of weather information, as well as the perceived value of a number of weather messages developed using the Weather Message Guidelines. Some assumptions underlying the development of the guidelines, such as the types of decisions that weather messages are intended to support, as well as basic traveler needs for weather messages, could be evaluated.
- Summarize the results and conclusions of the evaluations conducted with both the transportation agencies (state DOTs and individual TMCs) and travelers. Prioritize the changes needed and identify the perceived value of individual changes. Conduct a briefing with the FHWA on the project to this point and agree upon a plan for revising the Weather Message Guidelines to reflect the evaluation.

Revise the Weather Message Guidelines

- Revise the Weather Message Guidelines based on feedback received by end-users and travelers, in accordance to the agreed-upon plan and submit to the FHWA. This activity could be, potentially, as simple as reorganizing the information or changing the format/layout of the guidance. More likely, however, is that several of the guidelines may have to be re-written to change the information they provide or to refocus the information to better target end-user information needs. Another possibility is the development of additional chapters to cover design information that is identified as being a high priority, but not included in the current set of guidelines.
- Summarize all objectives, methods, and results in a final report.

Additional Considerations Associated with Obtaining Feedback from Travelers

As listed in the implementation activities above, a potentially useful source of information for refining and guidelines involves obtaining feedback about road weather messages from a small set of travelers. This could involve using the guidelines to compose new messages or messages for more challenging weather scenarios and then having travelers evaluate their effectiveness, in addition to how useful they are as a basis for making travel decisions. There are different ways to obtain traveler feedback, including a brief survey similar to the one described in Chapter 4 of this project. Alternatively, more detailed information can be obtained using focus groups. A focus group approach would also permit discussion of other relevant aspects of road weather message design, such as what information travelers use to make travel decisions and how this varies based on weather conditions and dissemination methods used.

Note that the time and costs associated with conducting these activities may be high relative to the amount of information obtained from travelers. This is especially true if any attempt is made to obtain data that are representative of the broader travelling public, which would require data collection in multiple geographic locations. Brief traveler surveys are easier to conduct on a smaller scale than focus groups, since the latter require significantly more effort to develop data collection materials/scripts and to analyze the data. However, both have unavoidable “overhead” requirements, such as getting IRB approval, developing data collection tools and protocols, data entry and analysis, etc. Moreover, using a traveler survey approach, such as described in Chapter 4 would also limit the nature of the information obtained, since the brief duration of these surveys only makes it possible to obtain information using short and simple questions, such as evaluating travelers understanding of specific messages.

One important drawback of obtaining feedback from travelers is if the traveler feedback clearly indicates that there are problems with the information provided, such as if a message is frequently misinterpreted, or assumptions about dissemination method usage are found to be wrong. The key issue in this case is that unless the travelers comprise a large and representative sample of drivers, it is unclear as to whether the problems identified are limited to the test sample or represent a problem that affects the broader traveler population. For example, Ullman et al. (2005) conducted a focus group study to determine the best ways to communicating high water levels on certain types of roadways. The results indicated that the travelers’ preferences for descriptors such as “flooding,” “high water,” and “deep water” across locations, as did their preferences for the term used to describe certain types of roadways (e.g., frontage vs. feeder vs. access road). If data had not been collected in multiple locations, the resulting design guidance may have recommended message wording that would not have been less effective in certain locations.

While this type of information can help identify problems with the message design or implementation, it much less useful for identifying specific solutions or improvements unless data collection was implemented in a careful and comprehensive manner.

Outreach Effort

We also believe that an Outreach Effort for the Weather Message Guidelines can also be initiated over the next 18 months.[4] The goal of outreach activities should be to attract, engage, and

[4] Some of the simpler aspects of this outreach effort (e.g., conference papers and informational flyers) could be implemented immediately or concurrent with the test and evaluation effort described earlier. More involved

involve the end-user community in the on-going process of using and improving the products produced in this project. In general, such activities could include presentations at professional meetings (such as the Transportation Research Board (TRB)), discussions at AASHTO meetings, and seminars, conferences, workshops, and webinars devoted to presenting and reviewing the materials from this project. We have conducted outreach activities for a number of similar projects in the past, and this experience provides us with some data that we can use to identify outreach methods that will be the most valuable, and to assess their costs and likelihood of success.

Table 33 below summarizes the most valuable outreach methods with respect to: costs, time to implement, advantages, disadvantages, and likelihood of success. These characterizations are, admittedly, somewhat subjective, but they do reflect the experience of the project team with these and other outreach methods. We should note that the precise costs and time to implement some of these options (e.g., workshops/presentations/forums) would depend on how many of these activities were conducted; also, some of these methods could be combined. "Likelihood of success," in this regard, reflects the likelihood that a given outreach method will effectively communicate the availability and status of the weather message guidelines to its intended target audience; i.e., those organizations and individuals responsible for the development and dissemination of road weather advisory and control messages.

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activities such as webinars and workshops should perhaps be scheduled after the Weather Message Guidelines have been revised to reflect the results of the test and evaluation activity.

Table 33. Characterization of most valuable outreach methods with respect to key selection criteria.

OUTREACH METHODS	Cost to Implement	Time to Implement	Advantages	Disadvantages	Likelihood of Success
Workshops	Medium	Medium	Can thoroughly describe the Weather Message Guidelines in an interactive environment.	Limited to those that can attend workshops.	Medium
Conference or Journal articles	Low	Low	Can thoroughly describe Weather Message Guidelines objectives, status, and progress.	It may be that few end-users regularly read conference or journal articles.	Low-Medium
Presentations at state/regional DOT meetings	Medium	Medium	Can thoroughly describe the Weather Message Guidelines in an interactive environment.	Limited to those states/regions where presentations are held	Medium
Web-based forums	Low-Medium	Low-Medium	Can thoroughly describe the Weather Message Guidelines in an interactive environment.	Are "one-shot" activities that end-users may not participate in.	Medium
E-mailing the Weather Message Guidelines	Low	Low	Can quickly disseminate the Weather Message Guidelines to many people.	E-mails may get lost or disregarded. Will not have the same impact as in-person presentations.	Low-Medium
Providing links to the Weather Message Guidelines on relevant websites	Low	Low	Can quickly disseminate the Weather Message Guidelines to many people.	Requires that end-users frequent the websites that we target. Will not have the same impact as in-person presentations.	Low-Medium

A review of Table 33 quickly reveals that there is no single outreach method that minimizes cost and time, while maximizing outreach efficacy. Indeed, all of the methods have their limitations and none—in isolation—provide a high likelihood of success. Our experience suggests that the most effective way to engage and inform the end-user community for the Weather Message Guidelines would be to implement all of the outreach methods listed in Table 33 at some level.

To augment these outreach activities the FHWA could distribute short 1-2 page flyers, brochures, etc. that describe this project and its products (an information flyer was developed as part of the current effort)). These can be distributed at meetings and conferences—at both the state and federal levels—to heighten awareness of the effort and the guidelines. The project can also be discussed in relevant DOT newsletters.

Materials for workshops, articles, conference presentations, and web-based forums could draw from the same basic set of materials provided to the FHWA as part of this and any future project and would therefore be available at a relatively low cost overall. Workshops and web-based forums, including a website specifically devoted to the Weather Message Guidelines—due to their interactive nature—might require the development of additional materials. E-mailing the guidelines and providing links to the guidelines on relevant websites are simple, low-cost outreach methods and, because they would be targeted specifically to end-users, can be expected to at least provide the guidelines to the chief target audience of the project.

Collectively, the outreach activities and materials should provide the following information:

- Objectives of the Weather Message Guidelines.
- Benefits and limitations of the Weather Message Guidelines.
- Content and format of the Weather Message Guidelines.
- Ways to use the Weather Message Guidelines.
- Development procedures and timeframe for the Weather Message Guidelines.
- Case studies, sample problems, areas of application, success stories.
- How end-user involvement has impacted the Weather Message Guidelines and their development.
- Ways that end-users can participate in the Weather Message Guidelines development process.
- Names and contact information for Weather Message Guidelines points-of-contact.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following three primary conclusions emerged from the work in this project:

1. The guidelines and recommendations developed in this project have the potential to improve the content and delivery of road weather information.

2. The guidelines and recommendations reflect best practices, as well as the best-available information from the research literature.

3. Additional activities should be conducted that focus on better tailoring the guidelines to end-users' preferences and requirements.

These conclusions are described below.

Content and Delivery of Road Weather Information

Although there was some uncertainty at the outset of this project regarding the availability and suitability of existing research for developing road weather message design guidelines, the work in Chapter 5 showed that by incorporating information from other related domains, it has been possible to develop design recommendations that apply to road weather messages. In particular, thirty separate guidelines were written covering a range of design topics for different dissemination types including 1) short-text/DMS, 2) open visual formats, and 3) auditory messages.

As noted in the preceding conclusions, there are gaps with regard to how well the available design recommendations cover specific road weather communication situations, and end-user information needs; however, there was sufficient applicable information from other related traveler-information domains to provide guidance grounded in empirical research in many cases. In other instances, such as with web-based content in which existing information was unavailable or insufficient, it was still possible to develop design recommendations based on best-practices and general human factors design principles. In general, there is enough relevant design information contained in the guidelines to assist end-users in improving their communication of road weather in the short term. Moreover, this preliminary set of design guidelines will support the process of obtain feedback from end-users by providing a starting point for discussions, and it also makes information "gaps" easier to identify for future research efforts.

Best Practices and Best-available Information

As stated in the previous paragraph, most data sources used to develop the design recommendations are not road weather-specific. While empirical research that directly addressed road weather messages would have likely provided the most relevant and specific information, the topics covered in the design guidelines were framed at a level that was general enough to permit us to use design information from other related domains as a basis for the design recommendations. We were able to cover key design topics in this manner; however, this approach likely missed many situation-specific design considerations and other nuances that are particular to road weather information. Contributing to this is that fact that end-users were not included in the guideline development process, so the guideline topics were not selected to specifically address the information requirements of TMCs or other end users. Although we have tried to make the best use of available information, the lack of road weather-specific information sources and involvement of the end-user community means that there still exists a need for more specific design information that is more closely focused on road weather communication.

Additional Activities

Up to this point, end-users have had no involvement in developing the content, format, and organization of the guidelines and recommendations. While the guidelines could be useful for a broad range of transportation professionals, the end-users that will be impacted the most by the organization, format, and content of the guidelines, and the ones that should be consulted most thoroughly for feedback, are the transportation professionals (e.g., TMC personnel and other state DOT staff) that develop or support the development of messages and strategies for communicating road weather information to travelers. Although the preliminary guidelines cover a wide range of general design topics, with a focus on road weather information when it was possible, the guidelines have not been specifically developed with key use cases in mind from the outset. This requires a better understanding of who the end-users are, what design information they require, at what stages in the design process is guidance required, and so forth. This type of information is not difficult to obtain, but it does require a targeted and formal process to obtain information that identifies specific user requirements and that adequately represents how the design information will be used. Additional information about obtaining this key information from end users is provided in the Recommendations section below.

Recommendations

Based on the results and findings from this project, the recommendations are presented as suitable future activities to continue advancing the development and implementation of the road weather message design guidelines. These recommendations include:

- Implement the evaluation plan with a goal of obtaining end-user feedback on the current guidelines.
- Revise the guidelines in accordance with the end-user recommendations.
- Implement the outreach activities in order to attract, engage, and involve the end-user community.
- Target areas for improving the guidelines.

These recommendations are discussed in more detail in the following sections.

Implement the Evaluation Plan with a Goal of Obtaining End-user Feedback on the Current Guidelines

The Implementation and Evaluation Plan contained in the Chapter 6 summary outlines several key activities related to preparing for and obtaining end-user feedback on the guidelines. In summary, these include:

- Preparing for the evaluation of the guidelines.
- Conduct evaluation of the guidelines.
- Revise the road weather message guidelines.

Conducting the activities outlined in the evaluation plan (these are also provided above in Chapter 6) will provide important feedback about the overall design, format/layout, and content of the guideline information, which provides sound basis for making key improvements to the road weather message design information.

Revise the Guidelines in Accordance with the End-user Recommendations

Although the previous activities resulted in a coherent set of message design guidelines based on the best available information, they have not been developed using a systematic process that incorporates the information and usage requirements of the intended end-user community. Accordingly, in some ways these guidelines represent "raw material" that can be modified to be more consistent with how end-users would use the guideline information for communicating road weather information and that is more focused on the specific information elements that end-users have. The evaluation plan for the guidelines is presented in Chapter 6, and it describes an approach for obtaining key information from end user that can be used to revise and generally improve the current set of guidelines.

Implement the Outreach Activities in order to Attract, Engage, and Involve the End-user Community

The activities listed in the outreach plan are relatively inexpensive, yet in combination provide an overall comprehensive approach for raising awareness about the guidelines. It is also worth noting that one of the most effective ways to attract and engage the end-users is to involve them in the development process. This promotes the view among end users that the document will be of value to them because their concerns, design issues, etc., were specifically taken into account during the guideline development process. Ultimately, this approach gives the end-user community a stake in the success of the guidelines, and encourages active promotion of the document among end-users themselves.

Target Areas for Improving the Guidelines

We have identified several key areas in which the guidelines can benefit from additional development and refinement. These areas are discussed below.

Organization: One area that requires validation and possible improvement is how the content is organized. This is a key step for ensuring that the document is accessible/easy to use, presented in a logical manner, and in a manner that supports how road weather message development is conducted. Ensuring that the guideline document has a good organization likely involve developing a functional integration of guidelines, tutorials, the traveler information needs design tool.

The guidelines should support key use cases, and contain the necessary supporting material. This includes introductory chapters that discuss the objective of guidelines and the rational for incorporating the guidance into the road weather communication design process. Other chapters should describe the elements/layout of the guidelines, information about how end-users can find the information they need, in addition to other related sections such as a glossary and index.

Another document organization issue is to determine the best use for the traveler information needs design tool that was described in Chapter 5. Although we think that the tool remains an effective way to define message content that takes into account the travelers information needs, it represents a relatively complex step in the message design process. One concern is that emphasizing a design tool could introduce a barrier if end-users perceived that this is a necessary step to using the design information, rather than a supplemental tool that aids the development of weather message content and presentation. The current organization is a holdover from earlier tasks, when there was greater uncertainty regarding the possibility of providing a broad range of design guidelines. The work in Chapter 5 established that there is sufficient design information to permit the guidelines to stand on their own, which leaves open the option of moving the design tool to a tutorial, or giving it a more optional/supplementary flavor when it is presented. Ultimately, this is an empirical question that is best answered by consulting end users.

Format

In previous guideline efforts, we have found that guidelines that use a consist format are well received and judged to be easy to use. In addition, using a consistent format is also important during the development of design guidelines. In particular, limitations in guideline length and clear definitions of what each section should cover demand discipline from guideline writers, which result in guidelines that are focused, pertinent, and address the key issues in a way that minimizes unnecessary narrative text. Although the current guidelines followed a basic format, the emphasis during their development was on presenting relevant content, rather than adhering to a strict format.

Although we have formats and style guides from other guideline development efforts that can be applied to the road weather message guidelines, it make sense to obtain feedback on the format from end-users to ensure that the guidelines are consistent with the specific ways in which end-users seek out and use design information. It is also important that the information be presented at the required level of detail.

Content

Up to this point, much of the content has been driven by what information is available with an overall objective of covering typical message-design information elements, and information that we perceived to be useful based on our understanding of existing practices. However, several questions remain about the nature of this information, including:

- Have we provided valuable information and answered the right questions?
- What additional information is needed?
- Are there other/better sources of guidance?

These are questions that the end-user community can best answer, and the guidelines should be revised accordingly.

General

There are some other more general questions that can also benefit from feedback from end users. These include:

- How well do the guidelines fit in with typical operational procedures at a TMC? Or state DOT?
- Is our use of terminology correct?
- Are there better examples that we could use?
- How well do the guidelines support the most common use-cases?

Obtaining answers to these questions and incorporating the feedback into the guideline documents is an important part of making them useful and relevant to end-users, and for ensuring that they will become valuable and widely-used resource that ultimately promotes effective and timely communication of road weather information to travelers.

CHAPTER 8. REFERENCES

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APPENDIX A. INFORMATION COLLECTED FROM STATE DOT CONTACTS AND WEBSITES

Table A-1. Summary of state DOT contacts and information.

State DOT	Contact Person	Outcome
Arizona (ADOT)	David Engliskis, Traffic Specialist	General statement that ADOT does post weather advisories on DMSs. Messages are posted for known conditions/ restrictions that affect the road condition or visibility. Examples would be winter storms or poor visibility during a dust storm.
Connecticut (ConnDOT)	Hal Decker, Principal Engineer	Received Scope of Work document for the Bridgeport Operations Center. Does not contain specific DMS policies/procedures.
Florida (FDOT)	Steven Corbin, ITS Operations Manager Peter Vega, P.E., ITS Operation Manager District 2 TMC Jacksonville	Summary of road weather posting procedures for DMSs. See comments below.
Idaho Transportation Department (ITD)	Steve Holland Mark Blackshaw, ITS Engineer Alison Lantz Traveler Information/511 Coordinator Jim Larson, Ada County Highway District (ACHD) Robert Koberline	From website manual published by ITD, criteria for using DMS messages for displaying weather information. See comments below.
Iowa (IDOT)	Willy Sorenson	IDOT's policy on putting winter-related messages on DMSs. See comments below.
Missouri (MoDOT)	Don Spenser	Summary of road weather posting procedures for DMSs. See comments below.
Nevada (NDOT)	Michael Fuess, District Traffic Engineer Connie Hagen, Lead Dispatcher Road Operations Center District 2, Dept. of Transportation	Road weather message policy and messages. See comments below.
Oregon (ODOT)	Gayland McGillum, ITS Unit Kelly Forbes ITS Operations Coordinator Intelligent Transportation Systems Office of Maintenance & Operations	List of road weather messages and link to policy. See comments below.
Texas (TxDOT)	Brian Burk, Austin District Thelma Rameriz, El Paso District Robin Frisk, Amarillo District	Examples of road condition messages. See screen captures below.
Utah (UDOT)	David Kinnecom Traffic Management Engineer Traffic Operations Center	Summary of use of DMSs. See comments below.
Washington State (WSDOT)	Bill Legg, State ITS Operations Engineer	Information on message policies. See comments below.

The following table contains the information provided by each DOT contact. Note that the information that was compatible with the database was incorporated into the database. The table below contains this same information, plus all other information that could not be included in the database.

Table A-2. Comments obtained from contacts.

Comments
Florida DOT ▪ FDOT does post weather-related messages on their DMSs -- mostly for heavy rain events, limited visibility. ▪ Each morning operators check the weather forecast to learn of coming fronts. ▪ As the front approaches, operators watch for brake lights in video. When they see, "a lot of brake lights," they know weather is impacting operations. They will then post messages upstream of the area to alert approaching drivers to bad weather. ▪ They generally use "canned" messages (waiting to receive list of messages).
Idaho Transportation Department (ITD) A *Traffic Manual* published by ITD is available at http://www.itd.idaho.gov/manuals/Online_Manuals/Traffic/Traffic.htm. ▪ Inside the manual there is a section of Intelligent Transportation Systems which includes information on DMSs. Table 501.11.01 is a summary of criteria for use of DMS signs. This table lists the following criteria for using DMS messages for displaying weather information: ▪ A reduction in visibility to 1000 feet or less (due to either fog or dust) ▪ The existence of icy pavement conditions ▪ The existence of high wind conditions ▪ The manual also states that road conditions messages due to weather are considered a "Traffic Management" priority (3 priority in list of 6). Also, the TMC located in Boise is operated by ACHD. ACHD is responsible for controlling traffic signal systems and arterial street cameras and (according to the website) has been working with ITD to make this a joint center that controls operations on all arterial streets within Ada County and the Treasure Valley Freeway System.
Iowa DOT Traffic and Safety Manual, Chapter 2, Permanent Changeable Message Signs Guidelines are available at http://www.iowadot.gov/traffic/manuals/pdf/02f.02.pdf. The excerpt below summarizes use of DMSs for road weather. “CMSs may be used to display adverse weather, environmental, or roadway conditions downstream that may impact driver visibility and safety (e.g., fog, major snow storms, sand storms, icy roadway, high cross winds, broken pavement, etc.), or advise motorists of specific regulations due to the weather or roadway conditions. Messages, when used, are restricted to a specific location and a specific CMS. The roadway condition must be in the vicinity of the sign in use. General weather, environmental, or roadway condition information (ICY ROAD CONDITIONS AHEAD) is not permitted.

Comments
By special arrangement with the National Weather Service it is permissible to display winter weather warnings when they are issued. The Lead Forecaster for the area involved is to make the determination and request that the appropriate sign(s) be activated in accordance with the National Weather Service in Des Moines internal Policy LPI 96-02.” Also, the policy below was developed for the use of DMSs for weather events.

Draft Updated 10-9-08

Chapter XX

DOT Winter Operations and DMS

Non-Winter types of Messages: During this pilot project of deploying weather messages, only winter related messages will be posted on DMS across Iowa. In the future he DOT will consider other weather related messages, such as Tornado, Flash Floods, High Winds, Fog, etc.

Priority: Weather messages are 4th on the list of priorities. Here is the entire list.

1) Incident information
2) AMBER Alerts
3) Advance Road Work/Special Events
4) Weather
    a. Expect Difficult Driving Conditions messages (Must be recommended by District)
    b. NWS Warnings
    c. Snow Plow Operations in Use – Winter Driving Conditions (Must be done or recommended by District staff)
    d. Snow Plows in use on Medians, Shoulders and Ramps
5) Public Service Announcements
6) Test Messages

Responsibilities:

For Winter Storm Warnings: In the past, the NWS (National Weather Service) has called the 24hr pager (877-999-4731) for District 1 staff in Des Moines and notified the DOT of a Winter Storm Warning. Beginning on November 1, 2008 the NWS will be directed to call the SEOPs 24/7/365 phone number of (515)-233-7900.

On some rare occasions, the NWS has been busy, and not called the DOT before a storm. SEOP Staff should monitor the NWS’s web page at www.nws.noaa.gov during possible storms and will need to determine when and what messages should be deployed.

For winter snow removal operations: District staff shall post messages, or request the SEOPS Center, on overhead DMS and Rest Area DMS based on their operations and weather in their area.

Agreement:

The Iowa DOT and the NWS (National Weather Service) have an informal agreement for posting of warnings on DMS dated 2/1/96 back to when we had DMS in Des Moines only. A copy of the letters back and forth from the DOT are included in the Appendix of this section.

Time Frames:

Winter storm warnings are usually issued by the NWS many hours before the storm will hit a region. DOT staff must consider many factors such as storm intensity, location of DMS, regions affected by the storm, etc. Messages should begin to be displayed on DMS for drivers that will enter the affected region and no other DMS will be seen by the driver. As a general rule of thumb, NWS warnings should be displayed 2 hours before the warning begins.

NWS Winter Weather Events:

National Weather Service Winter Weather Outlook, Watch, Warning and Advisories are:

Definitions from the NWS:

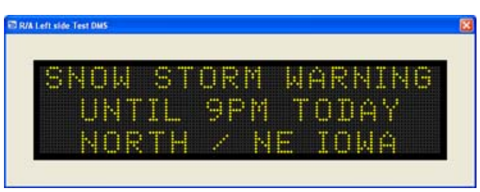
> **Outlook:** This information is shared in our daily Hazardous Weather Outlook for weather that may occur from two to seven days out.
>
> **Watch:** This information is sent out when winter storm conditions are possible within the next 36 to 48 hours.
>
> **Warning:** Life-threatening severe winter conditions have begun or will begin within 24 hours. Using the information found here and on associated links, take action now to make potentially life-saving decisions.
>
> **Advisory:** Winter weather conditions are expected to cause significant inconveniences and may be hazardous, especially for automobiles or early in the winter season. If you are cautious, these situations should not be life-threatening.
>
> **Heavy Snow Warning:** When snowfall of 6 inched or more in 12 hours or 8 inches or more in 24 hours is imminent or occurring. These criteria are specific for the Midwest and may vary regionally.

Overhead DMS Messages for each of the above issued events from the NWS:

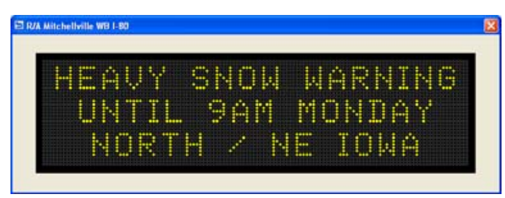
Outlook: No messages shall be displayed on the DMS.

Watch: No messages shall be displayed on the DMS

Warning: If a warning has been used, then display:



Or



After the warning has been used, and snow plows are out, continue to display the storm warning.

Advisory: No messages shall be displayed on the DMS

Comments

Warning: If a warning has been used, then display:

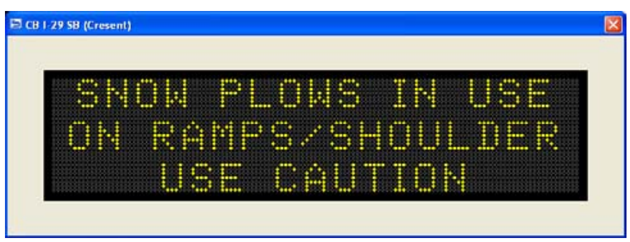
Or

After the warning has been used, and snow plows are out, continue to display the storm warning.

Advisory: No messages shall be displayed on the DMS

DMS Messages that can be used when DOT Snow plows are out and no NWS warnings:

Alternative: DMS Messages that can be used after a storm when it is not apparent that Snow Plows are on the roadway and ramps.



What signs should be used to display warnings?

The Iowa DOT staff person who is tasked with deploying winter weather messages has the responsibility and discretion to determine what DMS should get a message. The message could be displayed on all DMS (overhead and rest area) state-wide, however, consideration should be given to use only the DMS that have the possibility of drivers encountering the storm area.

What about "Click it or Ticket" messages and weather is bad?

If any PSA (Public Service Announcement) is being displayed on DMS and the weather is turning bad (snow in the winter, thunder storm/tornados in the summer) DOT staff should remove the message in their area and/or change the message that would be more appropriate. For example, the "Snow Removal Equipment in Use – Use Caution" message would be appropriate if snow is falling and plows are on the road.

Comments
Missouri (MoDOT) In METRO areas, MoDOT has been considering posting messages for known dramatic weather events (such as a tornado) but has not done so yet. They generally do not post general weather information (e.g., rain) because they want to reserve DMSs for specific or hazardous conditions. They will post messages related to ponding on roadway, generally indicating to slow down or do not enter. They will also post messages related to plowing operations. From SCOUT TMC, they do manage DMS on I-70 corridor which is used for weather events using a different set of messages.
Nevada DOT As a rule, NDOT does not post weather-related messages to advise motorists except in some high wind prone areas, when chains are required for snow events, or for potential road closures because of poor visibility due to sand storms (generally right before the road is closed). They have an automated system for posting wind advisory information Washoe Valley between Carson and Reno (See Best Practices in Road Weather Management for description of system). ▪ The wind-related messages are: HIGH WIND ADVISORY / NEXT 9 MILES / CAMPERS AND TRAILER / NOT ADVISED or HIGH WIND WARNING / NEXT 9 MILES / CAMPERS AND TRAILERS / PROHIBITED. ▪ All of the traction device advisories are basically: CHAINS OR SNOW TIRES REQUIRED / XX MILES AHEAD.
Oregon DOT The following messages are in the sign library used by the operators in dispatch. The Variable Message Sign (VMS) Guideline is available at: http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/pdf/Guidelines_for_VMS_on_State_Highway.pdf. ▪ 12 MILES AHEAD CHAINS REQ'D ON VEHS TOWING OR OVER 10K GVW ▪ 12 MILES AHEAD CHAINS REQ'D TRACTION TIRES ALLOWED VEHS UNDER 10K GVW AND NOT TOWING ▪ 16 MILES AHEAD CHAINS REQ'D ON VEHS TOWING OR OVER 10K GVW ▪ 16 MILES AHEAD CHAINS REQ'D TRACTION TIRES ALLOWED VEHS UNDER 10K GVW AND NOT TOWING ▪ BLOWING DUST AHEAD DUST NEXT 5 MILES ▪ BLOWING DUST AHEAD REDUCED VISIBILITY ▪ BLOWING DUST AHEAD REDUCED VISIBILITY ▪ BLOWING DUST AHEAD SLOW TURN ON LIGHTS ▪ BLOWING SNOW AHEAD LOW VISIBILITY ▪ BLOWING SNOW AHEAD SLOW TURN ON LIGHTS ▪ BLOWING SNOW AHEAD SNOW NEXT 10 MILES ▪ BLOWING SNOW AHEAD SNOW NEXT 2 MILES ▪ BLOWING SNOW AHEAD SNOW NEXT 3 MILES ▪ BLOWING SNOW AHEAD SNOW NEXT 4 MILES ▪ BLOWING SNOW AHEAD SNOW NEXT 5 MILES ▪ CARRY CHAINS OR TRACTION TIRES ▪ CARRY CHAINS OR TRACTION TIRES 12 MILES AHEAD ▪ CARRY CHAINS OR TRACTION TIRES 16 MILES AHEAD ▪ CARRY CHAINS OR TRACTION TIRES USE CAUTION ▪ CAUTION BLACK ICE AHEAD ▪ CAUTION FREEZING RAIN AHEAD

Comments
▪ CAUTION ICE SPOTS US 26 AND HIGHWAY 35
▪ CAUTION ICY AREAS AHEAD
▪ CAUTION ICY CONDITIONS AHEAD
▪ CAUTION SPOTS OF ICE AHEAD
▪ CHAIN CHECK POINT 2 MILES AHEAD INSTALL CHAINS NOW
▪ CHAINS OR TRACTION TIRES REQUIRED 10 MILES AHEAD
▪ CHAINS OR TRACTION TIRES REQUIRED 15 MILES AHEAD
▪ CHAINS OR TRACTION TIRES REQUIRED 16 MILES AHEAD
▪ CHAINS OR TRACTION TIRES REQUIRED 4 MILES AHEAD
▪ CHAINS OR TRACTION TIRES REQUIRED TIMBER- LINE RD
▪ CHAINS OR TRACTION TIRES REQUIRED HWY 35 & TIMBER- LINE ROAD
▪ CHAINS OR TRACTION TIRES REQUIRED TIMBERLINE RD AND HIGHWAY 35
▪ CHAINS REQD MP XX - XX MP XX - XX VEHS TOWING OR OVER 10,000 GVW
▪ CHAINS REQD MP XX - XX MP XX - XX VEHS TOWING OR UNDER 10,000 GVW
▪ CHAINS REQ'D ON VEH TOWING OR OVER 10000 XX MILES AHEAD
▪ CHAINS REQ'D TRACTION TIRES ALLOWED VEHICLES UNDER 10K GVW
▪ CHAINS REQUIRED
▪ CHAINS REQUIRED 20 MILES AHEAD EXPECT DELAYS
▪ CHAINS REQUIRED 70 MILES AHEAD EXPECT DELAYS
▪ CHAINS REQUIRED 9 MILES ASHLAND TRAFFIC USE EXIT 19
▪ CHAINS REQUIRED ALL VEHICLES 4X4'S TOWING
▪ CHAINS REQUIRED CHAIN UP AREA 12 MILES AHEAD TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA 18 MILES AHEAD TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA 2 MILES AHEAD TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA 24 MILES AHEAD TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA 6 MILES AHEAD TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA 7 MILES AHEAD TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA AT EXIT 252 TRACTION TIRES ALLOWED ON VEHICLE UNDER 10000 GVW
▪ CHAINS REQUIRED CHAIN UP AREA XX MILES AHEAD TRACTION TIRES ALLOWED ON VEHS UNDER 10000 GVW
▪ CHAINS REQUIRED HWY 26
▪ CHAINS REQUIRED HWY 35
▪ CHAINS REQUIRED HWY 35 AND TIMBER- LINE ROAD
▪ CHAINS REQUIRED INSTALL CHAINS NOW
▪ CHAINS REQUIRED MP XX - XX VEHS TOWING OR OVER 10,000 GVW
▪ CHAINS REQUIRED MP XX - XX VEHS TOWING OR UNDER 10,000 GVW
▪ CHAINS REQUIRED ON ALL VEHICLES 4X4'S TOWING CHAINS REQUIRED 2 MILES AHEAD

Comments
▪ CHAINS REQUIRED ON ALL VEHICLES 4X4'S TOWING CHAINS REQUIRED 3 MILES AHEAD
▪ CHAINS REQUIRED ON ALL VEHICLES 4X4'S TOWING CHAINS REQUIRED 4 MILES AHEAD
▪ CHAINS REQUIRED ON SINGLE AXLE TRUCKS TRUCKS W/ DOUBLES CHAINS REQUIRED 3 MILES AHEAD ON VEHICLES TOWING
▪ CHAINS REQUIRED ON SINGLE AXLE TRUCKS TRUCKS W/DOUBLES CHAINS REQUIRED 4 MILES AHEAD ON VEHICLES TOWING
▪ CHAINS REQUIRED ON VEH TOWING OR OVER 10000 GVW 12 MILES AHEAD
▪ CHAINS REQUIRED ON VEH TOWING OR OVER 10K GVW
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA 12 MILES AHEAD
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA 24 MILES AHEAD
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA 6 MILES AHEAD
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA 7 MILES AHEAD
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA AT EXIT 244
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA AT EXIT 249
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CHAIN UP AREA AT EXIT 252
▪ CHAINS REQUIRED ON VEHICLES TOWING OR OVER 10000 GVW CONGESTION THROUGH TRAFFIC USE LEFT LANE
▪ CHAINS REQUIRED SINGLE AXLE TRKS TRUCKS W/DOUBLES CHAINS REQUIRED 2 MILES AHEAD VEHICLES TOWING
▪ CHAINS REQUIRED SINGLE AXLE TRUCKS 4X4'S TOWING
▪ CHAINS REQUIRED TIMBER- LINE ROAD
▪ CHAINS REQUIRED TRACTION TIRES ALLOWED ON VEHS UNDER 10,000 GVW AND NOT TOWING
▪ CHAINS REQUIRED TRUCKS WITH DOUBLES
▪ CHAINS REQUIRED XX MILES AHEAD TRACTION TIRES ALLOWED ON VEH UNDER 10000 GVW
▪ CLOSED TO OVERSIZED USE EXIT 216 CHAINS REQUIRED XX MILES AHEAD
▪ CLOSED TO OVERSIZE DUE TO FOG USE EXIT 216
▪ CLOSED TO OVERSIZE DUE TO FOG USE EXIT 216 CHAINS REQUIRED ON TRUCKS XX MILES AHEAD
▪ CLOSED TO OVERSIZE DUE TO FOG USE EXIT 265
▪ CLOSED TO OVERSIZE DUE TO FOG USE EXIT 265 CHAINS REQUIRED ON TRUCKS XX MILES AHEAD
▪ CONDITIONAL CLOSURE ALL VEHICLES MUST USE CHAINS
▪ DENSE FOG AHEAD FOG NEXT 1 MILE
▪ DENSE FOG AHEAD LOW VISIBILITY
▪ DENSE FOG AHEAD SLOW TURN ON LIGHTS
▪ DENSE FOG AHEAD USE CAUTION
▪ DENSE FOG XX MILES AHEAD
▪ EXTREME ICY COND USE CAUTION
▪ EXTREMELY ICY CONDITIONS USE CAUTION
▪ EXTREMELY ICY CONDITIONS XX MILES AHEAD
▪ FOG AHEAD FOG NEXT 10 MILES
▪ FOG AHEAD FOG NEXT 2 MILES
▪ FOG AHEAD FOG NEXT 3 MILES
▪ FOG AHEAD FOG NEXT 4 MILES
▪ FOG AHEAD FOG NEXT 5 MILES

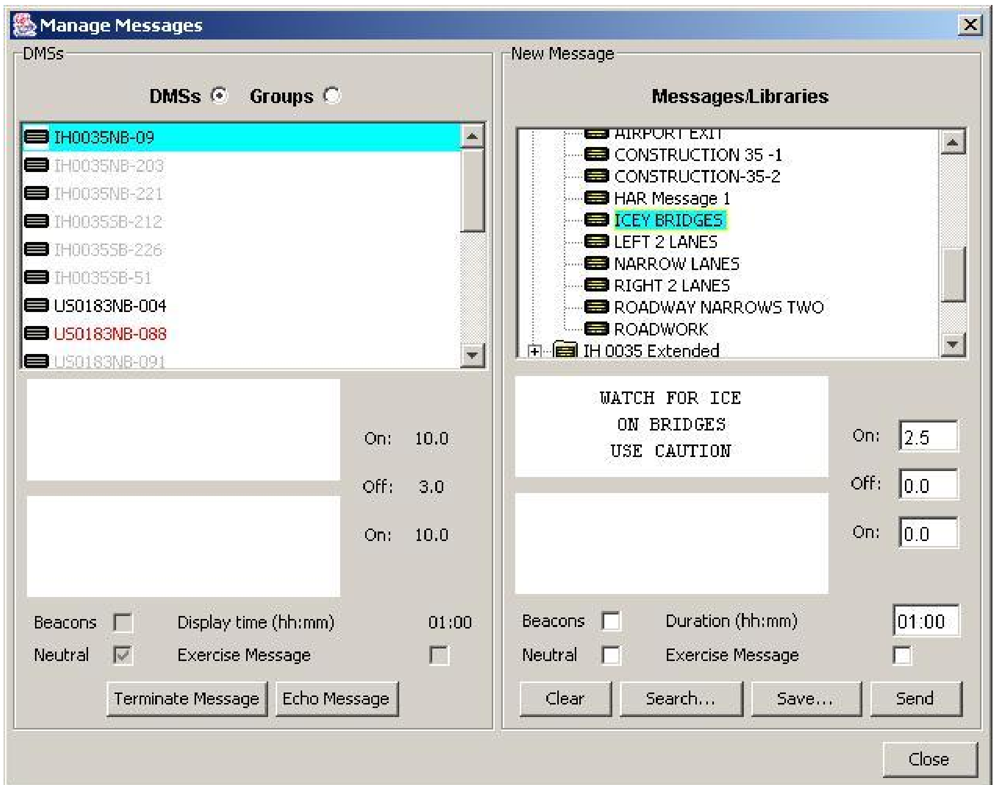
Comments
▪ FREEWAY CLOSED USE EXIT 216 2 MILES AHEAD ▪ FREEZING FOG AHEAD EXTREME HAZARD ▪ FREEZING FOG EXTREME HAZARD ▪ FREEZING FOG WEATHER EXTREME HAZARD ▪ I-84 CLOSED TO OVERSIZE LOADS XX MILES AHEAD DENSE FOG ▪ ICE ON BRIDGE SLOW ▪ ICE ON ROAD AHEAD SLOW TURN ON LIGHTS ▪ MEACHAM CLOSED TO ALL OVERSIZE DUE TO FREEZING FOG ▪ MEACHAM CLOSED TO ALL OVERSIZE DUE TO ROAD CONDITIONS ▪ OR 58 CHAINS REQ ON VEHICLES TOWING OR OVER 10KGVW ▪ OR 58 CHAINS REQ TRACTION TIRES ALLOWED VEHS UNDER 10K GVW AND NOT TOWING ▪ POSSIBLE BLACK ICE USE CAUTION ▪ POSSIBLE FREEZING FOG USE CAUTION ▪ ROAD FLOODED SLOW ▪ SEVERE WINTER CONDITIONS AHEAD ▪ SEVERE WINTER WEATHER AHEAD ▪ SLIPPERY RAMP AHEAD WARNING ▪ SLIPPERY ROAD AHEAD WARNING ▪ SNOW AND ICE NEXT XX MILES USE CAUTION ▪ SNOW BLOWERS AHEAD DO NOT PASS ▪ SNOW BLOWERS AHEAD USE LEFT LANE ▪ SNOW BLOWERS AHEAD USE RIGHT LANE ▪ SNOW PLOW AHEAD DO NOT PASS ▪ SNOW REMOVAL EQUIPMENT NEXT XX MILES TRUCKS USE RIGHT LANE ONLY ▪ SNOW ZONE AHEAD CARRY CHAINS OR TRACTION TIRES ▪ SNOW ZONE CARRY CHAINS OR TRACTION TIRES ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED 10 MILES AHEAD ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED 15 MILES AHEAD ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED 4 MILES AHEAD ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED 6 MILES AHEAD ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED HIGHWAY 35 ▪ SNOW ZONE CHAINS OR TRACTION TIRES REQUIRED ON TIMBERLINE RD ▪ SNOW ZONE CHAINS REQD ON VEHS TOWING OR OVER 10,000 GVW ▪ SNOW ZONE CHAINS REQUIRED ▪ SNOW ZONE CHAINS REQUIRED TRACTION TIRES ALLOWED ON VEH UNDER 10,000 GVW ▪ SNOW ZONE CHAINS REQUIRED ALL VEHICLES ▪ SNOW ZONE CHAINS REQUIRED HIGHWAY 26 ▪ SNOW ZONE CHAINS REQUIRED HIGHWAY 35 ▪ SNOW ZONE CHAINS REQUIRED HIGHWAY 35 AND TIMBERLINE RD ▪ SNOW ZONE CHAINS REQUIRED TIMBERLINE RD ▪ SNOW ZONE CHAINS REQUIRED UND 10K TRACTION TIRES OK ▪ WATCH FOR ICE ICE NEXT 1 MILE

Comments

- WATCH FOR ICE ICE NEXT 2 MILES
- WATCH FOR ICE ICE NEXT 3 MILES
- WATCH FOR ICE ICE NEXT 4 MILES
- WATCH FOR ICE ICE NEXT 5 MILES
- WATER CROSSING ROAD SLOW
- WINTER DRIVING CONDITIONS AHEAD

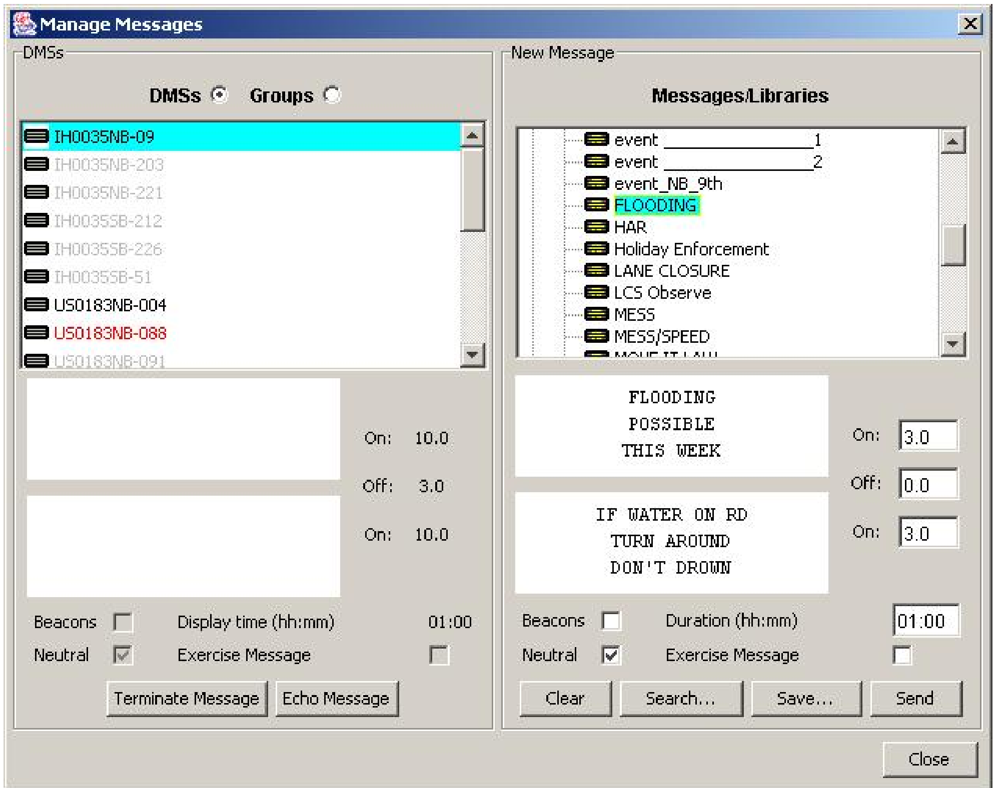
Texas (TxDOT)

Icy Bridges

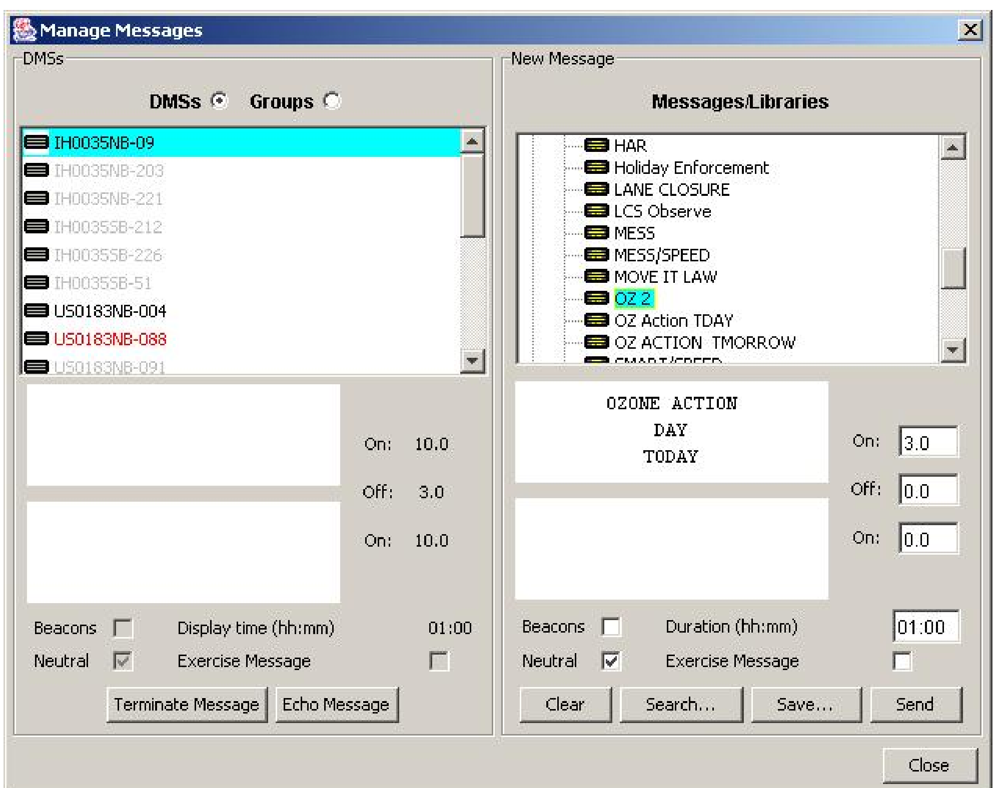


Comments

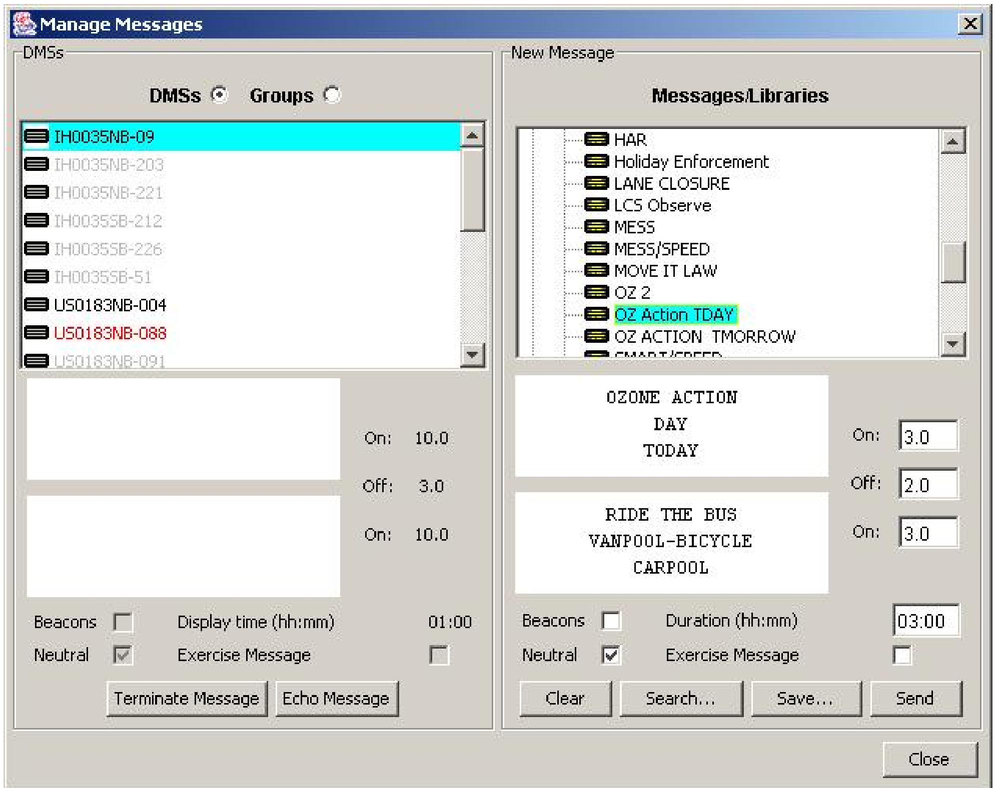
Flood



Ozone



Comments



Utah DOT

- At the request of the Utah Highway Patrol (UHP), DMSs were used to post advisory speeds during snow storms in mountain passes, but the practice was stopped after UHP Administration felt that posting an advisory speed could limit their ability to enforce "unsafe driving for conditions" citations.
- UDOT does NOT use DMS signs with weather conditions that are obvious (i.e., Snowing, Use Caution). They only use signs to warn motorists when a condition is UNEXPECTED. For example, signs will generally be used at night a day or two after a storm where moisture in the air or snow runoff might cause black ice to form. If conditions are right for Black ice to possibly form, the message is "BLACK ICE POSSIBLE USE CAUTION" or "ICY BRIDGE POSSIBLE USE CAUTION." If presence of black ice is known (observed by spinouts by video or reports from UHP) message is "BLACK ICE REDUCE SPEED."
- UDOT also uses DMSs to warn motorists of unexpected dramatic change. For example, it may be raining in the valley but snowing heavily in the mountain pass. They use signs to warn approaching motorists. Message is "WINTER DRIVING CONDITIONS AHEAD X MILES."
- UDOT also uses DMSs to advise motorists of four-wheel drive/chain law restrictions. UHP does not consider DMSs to be legally enforceable. In this application, UDOT always has regulatory signs with flashers activated and uses DMSs as a supplement to the signs.
- UDOT has used DMSs to warn of flooding conditions (section of roadways that are flat and susceptible to ponding). Operators know where these locations are and what conditions cause flooding. If these conditions are suspected by an operator, the message might be "FLOODING POSSIBLE USE CAUTION". If the condition is known, the message is "FLOODING AHEAD REDUCE SPEED"

Comments
▪ In the Western desert area, the highway runs east-west through flat open sections. They get strong winds from the south that have been known to turn semis over. UHP will close highway to trucks. When this occurs, UHP will notify UDOT that the highway is closed to semis. UDOT will post messages on DMSs when this occurs using a message such as "HIGH WINDS CLOSED TO SEMIS."
Washington (WSDOT) In general, WSDOT does not post weather-related messages on their VMSs, per the statewide VMS policy. Weather related hazards shall only be displayed if there is a need to inform motorists of an unexpected condition. VMSs will not generally be used to display road conditions due to apparent weather (e.g. icy roads during freezing winter weather). An exception may be to alert motorists to hazardous weather-related roadway conditions IF identifying a specific location, and using a specific sign (e.g. using the SR-3 N. sign with the following message "Ice on Roadway, 3 miles ahead at Sherman Hill" or the SR-16 VMS for "Severe side winds at Narrows Bridge") and the information is received and verified from reliable sources. Below are some, but not all, specific messages that may be used. The approach is to post messages for conditions that would be unexpected. For example, if motorists have been driving in fog for several miles they would not typically see a VMS message about fog, the message would have shown up on a sign ahead of entering the fog condition. ▪ Areas of Dense Fog/Poor visibility ▪ Compact Snow and Ice ▪ Blowing Dust/Poor Visibility ▪ Limited Visibility ▪ Areas of Standing Water ▪ Standing Water on Roadway ▪ Slush on Roadway ▪ Ice on Roadway ▪ Severe Side Winds Note that many of these messages may be followed by "Ahead" depending on the location of the problem related to the location of the sign.

Table A-3. State DOT website weather information elements.

State	Is there a Daily Weather Update?	Is a map shown on the weather page?	Is weather information for specific locations provided?	Are road weather conditions on Interstate highways provided on a dedicated map or table?	Are road weather conditions for state, local or other roads provided on a dedicated map or table?	Does weather information include links to other states or regions?	Are special conditions noted (e.g., hurricanes, snow, tornadoes)?
Alabama			✓				✓
Alaska	✓	✓		✓	✓	✓	
Arizona							
Arkansas				✓	✓		
California						✓	✓
Colorado	✓		✓			✓	
Connecticut	✓		✓				
Delaware	✓						
District of Columbia (Washington DC)							✓
Florida							✓
Georgia	✓	✓	✓			✓	✓
Hawaii							
Idaho		✓	✓	✓	✓	✓	
Illinois				✓	✓	✓	
Indiana	✓	✓	✓	✓	✓		
Iowa		✓	✓	✓	✓	✓	
Kansas	✓	✓	✓	✓	✓	✓	
Kentucky		✓	✓	✓	✓	✓	
Louisiana	✓		✓	✓	✓		
Maine			✓	✓	✓		
Maryland	✓		✓	✓	✓		
Massachusetts							
Michigan		✓		✓	✓	✓	

State	Is there a Daily Weather Update?	Is a map shown on the weather page?	Is weather information for specific locations provided?	Are road weather conditions on Interstate highways provided on a dedicated map or table?	Are road weather conditions for state, local or other roads provided on a dedicated map or table?	Does weather information include links to other states or regions?	Are special conditions noted (e.g., hurricanes, snow, tornadoes)?
Minnesota	✓	✓	✓	✓	✓	✓	
Mississippi	✓	✓	✓				
Missouri				✓	✓		
Montana	✓		✓				✓
Nebraska	✓	✓	✓	✓	✓		
Nevada		✓	✓	✓	✓		
New Hampshire	✓	✓	✓			✓	
New Jersey		✓		✓	✓		
New Mexico		✓	✓	✓	✓	✓	
New York		✓	✓	✓	✓		
North Carolina		✓	✓	✓	✓		
North Dakota		✓	✓	✓	✓	✓	
Ohio		✓		✓	✓		
Oklahoma				✓	✓		
Oregon		✓	✓	✓	✓		
Pennsylvania							
Rhode Island	✓	✓	✓	✓	✓		
South Carolina	✓	✓					
South Dakota	✓	✓	✓	✓	✓		
Tennessee		✓		✓	✓		
Texas	✓			✓	✓		
Utah		✓		✓	✓		
Vermont		✓		✓	✓		
Virginia	✓			✓	✓		
Washington State	✓		✓	✓	✓		

State	Is there a Daily Weather Update?	Is a map shown on the weather page?	Is weather information for specific locations provided?	Are road weather conditions on Interstate highways provided on a dedicated map or table?	Are road weather conditions for state, local or other roads provided on a dedicated map or table?	Does weather information include links to other states or regions?	Are special conditions noted (e.g., hurricanes, snow, tornadoes)?
West Virginia	✓	✓	✓	✓	✓		
Wisconsin	✓		✓	✓	✓		
Wyoming	✓	✓	✓	✓	✓		✓
*Total "✓"	23	28	29	35	35	14	7
**Percent "✓"	45%	55%	57%	69%	69%	27%	14%

APPENDIX B. DATA SOURCE SUMMARIES

The following data sources were reviewed. Individual data source summaries follow on subsequent pages.

Andrey, J., Mills, B., and Vandermolen, J. (2001). *Weather information and road safety* (Paper Series – No. 15). Toronto, Ontario, Canada: Institute for Catastrophic Loss Reduction.

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Study Type Analytical Study	**Dissemination Methods** General
Weather Impacts/Conditions General	
Study Objectives To assess the state of knowledge about the role of weather information in road safety improvement.	
General Approach Selective research reviews related to road weather information needs (among other topics) were conducted, organized by research question.	
Methods Sources reviewed included: • Peer-reviewed literature in field of transportation engineering and planning, risk assessment, and applied climatology. • Other related sources, including: government documents, consultation reports, conference proceedings, and web pages.	
Findings Topics related to road-user information needs that were addressed: • What types and sources of weather information are used by drivers in making travel decisions? • What types of adjustments are made in light of weather information? • What are the safety implications of these adjustments? • Do drivers need or want more or improved weather information? • How might more or improved weather information be used? • What is the value of more or improved weather information?	
Evaluation • The article provides some information on a range of important topics related to driver information needs. The amount of methodological information provided is limited and it is unclear how systematic the review was.	
General Comments Winter road maintenance issues were also discussed.	

Document Reference

Ballard, A. J., Ullman, B. R., Trout, N. D., Venglar, S. P., Borchardt, D. W., Voight, A. P., et al. (2008). *Hurricane evacuation traffic operations* (FHWA/TX/-08/0-4962-1). College Station: Texas Transportation Institute. Retrieved September 9, 2008 from http://tti.tamu.edu/documents/0-4962-1.pdf.

Study Type	**Dissemination Methods**
Focus Group, Laboratory Study	Traffic Signs, Pavement Markings, Dynamic Message Sign

Weather Impacts/Conditions

Hurricanes

Study Objectives

To identify road-user information needs and assess various hurricane evacuation traffic signs and pavement markings for developing guidelines.

General Approach

Focus groups and laboratory studies involving motorists were used to obtain direct evaluations of evacuation-related signs, traffic control, and information needs.

Methods

Focus Groups

- 8 to 10 motorists in 4 different locations (37 in total) that had participated in recent hurricane evacuations participated in single-session, moderated focus groups.
- Participants discussed signing alternatives, traffic control techniques, and motorist information needs.

Laboratory Study

- 421 licensed drivers participated at in-person surveys/interviews in which they viewed pictures of road signs and markings and evaluated them along specific dimensions (e.g., understanding, accuracy, etc).

Findings

Focus Groups

- The focus groups provided information about drivers' understanding of evacuation-related signage and traffic control, and identified different prioritized sets of information needs at each site.

Laboratory Study

- The report provides data comparing different signage and pavement options for various communication messages and methods, including DMSs.

Evaluation

- Focus groups seemed to be effective for identifying a broad range of information requirements and their relative priority. These results, while useful and informative, are not generalizable.
- The laboratory study provided a visually-accurate method for presenting signs and markings for evaluation. The comparisons between different signage/marking options appear to be valid.

General Comments

None.

Document Reference

Bhise, V. D., and Ambeti, Y. R. G. (2007). Effects of simulated Internet tasks on driving performance. *Proceedings of the Transportation Research Board 86th Annual Meeting [CD-ROM]*.

Study Type	**Dissemination Methods**
Laboratory Study	Personal Electronic Device

Weather Impacts/Conditions

General

Study Objectives

To examine the effect of accessing Internet-based information on driving performance.

General Approach

A fixed-based simulator was used to measure driving performance using different information access methods (e.g., touch pad vs. voice activation).

Methods

- 20 participants drove a 12-minute simulator route 3 times. First without any information retrieval, then once each using the touch pad and voice activation retrieval methods.
- Participants had to obtain different types of information (e.g., weather messages, stock quotes, etc).
- The simulator provided a 30 degree horizontal field of view.

Findings

- Accessing Internet information doubled lane-position variability in the touch screen position and to a lesser degree in the voice-activated condition (20% less).
- There was a small but non-significant reduction in speed during these tasks.

Evaluation

- This driving simulator approach has limited use for evaluating potential safety impacts of specific aspects of information dissemination approaches (i.e., information access in this case).
- More subtle aspects of dissemination approach, such as information content, are unlikely to be associated with sufficiently strong impacts on driver performance to make this approach feasible.

General Comments

In general, compelling results are challenging to obtain using this approach.

Document Reference

Boon, C. B. and Cluett, C. (2002). *Road weather information systems: Enabling proactive maintenance practices in Washington State* (TRAC Research Project T1803, Task 39, Report Prepared for the Washington State Transportation Commission). Seattle, WA: Washington State Transportation Center (TRAC).

Study Type	**Dissemination Methods**
Survey	Website

Weather Impacts/Conditions

Winter Conditions

Study Objectives

To better understand who used the site, what kind of trips users were planning with the site information, which features they used, how these might be improved, and what suggestions they had for enhancing the site.

General Approach

A brief Internet-based survey was used to obtain information from rWeather website visitors.

Methods

- Visitors to the WSDOT rWeather website were invited to respond to a short on-line survey conducted in the spring of 2001.
- 140 members of the public completed the survey.

Findings

- Survey respondents gave a positive assessment of the value of the website in helping them prepare for their travel and road weather conditions.
- Most common suggestions included: more camera images, more current information, broader and more consistent geographic coverage, and some site design modifications.

Evaluation

- This appears to be an easy way to obtain information about website user preferences, assuming that the appropriate arrangements can be made with the website providers. There are likely to be issues related to the generalizability of the results based on how participants are recruited.

General Comments

None.

Document Reference

CJ Olson Market Research. (2000). *Qualitative research regarding road and weather information technology*. St. Paul: Minnesota Department of Transportation. Retrieved September 9, 2008 from http://www.dot.state.mn.us/guidestar/1996_2000/statwide_atis/atis9900.pdf.

Study Type	**Dissemination Methods**
Focus Group	TV, Radio, Websites, Kiosks, 1-800 Telephone Numbers

Weather Impacts/Conditions

Winter Conditions

Study Objectives

To identify the strengths and weaknesses of various road condition information systems available to Minnesota motorists.

General Approach

Six focus groups in Minnesota cities were conducted regarding available road condition information systems.

Methods

- Focus groups were conducted in six different Minnesota cities.
- A general public sample was purchased for each city to serve as a call-out recruiting list.
- In addition to general discussions, four specific approaches were directly compared: Websites, Kiosks, 1-800 Telephone Numbers.

Findings

- The most common sources for road and weather information were: TV News, Radio, Cable TV Channels, and the Internet.
- There seemed to be loyalty among Minneapolis participants regarding the local TV and radio stations they used for weather information.
- In some locations, participants were dissatisfied with the available information or did not receive adequate local information.
- With regard to likelihood of use for the four methods directly compared:
  - Websites: Mixed response.
  - 1-800 Telephone Numbers: Most were unlikely to use (this had the highest awareness).
  - Kiosks: Most were unlikely to use them, but rural participants viewed these more favorably (this had the lowest awareness).
  - Cable TV Channels: Most were likely to use.
- Overall, Cable TV Channels were the most used information source.
- More detailed information about perceived advantages and disadvantages of various methods is also provided.

Evaluation

- Conclusions about Internet use likely to be out of date, since general Internet use has increased since that time.

General Comments

None.

Document Reference

Cluett, C., Jenq, J. H., and Saleem, F. (2003). Traveler information dissemination using WAP-enabled cell phones. *Proceedings of the ITS America 13th Annual Meeting & Exposition* [CD ROM].

Study Type	**Dissemination Methods**
Field Study	Personal Electronic Device, Cellular Phone Messaging

Weather Impacts/Conditions

General

Study Objectives

To evaluate the advantages and disadvantages of using a specific cellular-based personal device for providing road weather information.

General Approach

PEDs that provided web-based and text-messaging capabilities related to road-weather information were provided to participants, who were later interviewed about their opinions about using these devices for obtaining road-weather information.

Methods

- WAP cellular devices were provided to selected individuals working transportation agencies in Phoenix, AZ.
- The devices provided limited Internet browsing capabilities and text-messaging/e-mail "information push" capabilities.
- 13 participants were interviewed over the phone after using the device for one year.

Findings

- Overall, the devices were well received and used often by most participants.
- Several detailed findings are discussed pertaining to the aspects of this technology that participants liked and disliked.
  - Key limitations included inadequate availability information about routes most commonly traveled and difficulties operating specific features of the devices.
  - One key advantage identified was the ability to receive "alerts" regarding specific routes they frequently traveled.

Evaluation

- The generalizability of the findings is limited, given the selected participant population and small number of respondents. Also, opinions are likely to be changing as participants become more familiar with the devices.

General Comments

None.

Document Reference

Cluett, C., Kitchener, F., Frevert, B., Conger, S. (2004). Evaluation of the U.S. 395 Road-Weather ITS Systems: FY99 Federal Earmark, Spokane, Washington (ITS2004-000320.pdf). *Proceedings of the ITS America 14th Annual Meeting & Exposition* [CD ROM].

Study Type	Dissemination Methods
Survey/Interview	Highway Advisory Radio, Website

Weather Impacts/Conditions

Winter Conditions

Study Objectives

To assess the benefits of new road-weather information system components installed in the U.S. 395 corridor.

General Approach

Interviews and web surveys were used to evaluate the benefits of the Washington State Department of Transportation (WSDOT) HAR system and traveler information and road-weather web pages used by Commercial Vehicle Operators (CVOs) and the driving public in general.

Methods

- Interviews with 39 CVOs were conducted before and after they were informed about the existence of the information systems.
- Public motorist opinions were solicited using a web-based survey was conducted on WSDOT traveler information and road-weather web pages
- Article does not provided detailed methodological information
- Survey period was during the 2002-2003 winter travel months (Dec-Mar)
- 237 website visitors participated

Findings

Commercial Vehicle Operators

- Study provides findings regarding impact of road condition information on information access and use, route selection, and overall preparedness.

Motorists

- Study provides findings regarding impact of road condition information on information access and use, trip origin (in-state and out-of-state), trip planning, route selection, and overall preparedness, use of website features, confidence in the information, and potential improvements in information dissemination.

Evaluation

- This appeared to be a reasonably effective approach for obtaining opinions of website information users, although the standard caveats regarding generalizability of the sample still hold. There is insufficient methodological information provided about the CVO interviews, however, the information obtained is relevant.

General Comments

None.

Document Reference

Drobot, S. (2008). Driving decisions related to the Colorado front range winter storm, December 20-21, 2006. *Transportation Research Circular E-C126: Surface Transportation Weather; Snow and Ice Control*, 597-607. Retrieved September 9, 2008 from http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf

Study Type	**Dissemination Methods**
Survey	General

Weather Impacts/Conditions

Winter Conditions

Study Objectives

To improve understanding of decision making related to driving in hazardous winter weather conditions.

General Approach

An Internet survey was used to obtain information on respondents' sources, uses, and perception of weather forecasts; their driving decisions related to a particular winter storm; and basic demographic characteristics.

Methods

- 235 participants who had experienced severe winter storm conditions along the Colorado Front Range responded to questions in an Internet-based survey.
- Respondents answered questions to determine their main source of weather information, decision to stay home during the storm, and perception of weather forecast accuracy (timing and severity).
- Survey questions were related to a single severe winter storm event from December 20–21, 2006.

Findings

- The vast majority of respondents relied on local television to get weather information leading up to and during the storm.
- A majority of respondents felt that the snow began to fall approximately when it was forecast to begin, but believed that more snow fell than was forecast.
- Results related to behavior included percentage of respondents who stayed at home, their anxiety levels, and special precautions taken by those who did not stay at home.

Evaluation

- The report provides limited information about drivers' choice of information source. The amount of methodological information provided is limited with very few details about the survey design.

General Comments

None.

Document Reference

Dudek, C. L., Schrock, S. D., Ullman, G. L. (2005) *Impacts of using dynamic features to display messages on changeable message signs* (FHWA-HOP-05-069). Washington, DC: Federal Highway Administration.

Study Type	**Dissemination Methods**
Laboratory Study	Dynamic Message Sign

Weather Impacts/Conditions

General

Study Objectives

To evaluate three different types of DMS presentation formats with dynamic features in a simulated driving environment.

General Approach

A driving simulator was used to compare message comprehension and driving performance impacts for three different DMS presentation formats with different dynamic features.

Methods

- 64 drivers drove pre-planned driving routes in the driving simulator designed to subject drivers to high concurrent workload during DMS presentation.
- Three different presentation formats were used, including: 1) flashing entire one-phrase message, 2) flashing one line of a one-phrase message, and 3) alternating text on one line of a three-line message.
- Measures of Effectiveness (MoEs) included: reading times, comprehension, preference, accelerator variability, lane position measures, and headway distance measures.
- Follow-up questions about specific DMS presentations provided additional information about comprehension and preference, etc.

Findings

- Reading times were not higher for flashing messages than for static messages.
- Flashing messages may have adverse effects on message comprehension for unfamiliar drivers.
- Alternating line messages (with redundancy) had significantly longer reading times, but these messages were preferred.

Evaluation

- The study provided empirical validation of specific design approaches (i.e., presentation format). The driving performance MoEs may not accurately reflect actual driving performance effects because the display of the DMS was unrealistic (e.g., a static box with constant visual angle) and not integrated with the visual scene.

General Comments

None.

Document Reference
Dudek, C. L., Ullman, B. R., Trout, N. D., Finley, M. D., and Ullman, G. L. (2006). *Effective message design for dynamic message signs* (Report No. FHWA/TX-06/0-4023-5; 0-4023-5). College Station: Texas Transportation Institute.

Study Type	**Dissemination Methods**
Focus Group, Laboratory Study	Dynamic Message Sign

Weather Impacts/Conditions
General, Hurricanes, Flooding

Study Objectives

To provide recommendations for improving the effectiveness of DMS messages based on qualitative and quantitative data collected from drivers.

General Approach

Focus groups and laboratory studies were used to obtain driver feedback concerning DMS message information needs and potential problems with message understanding and other deficiencies.

Methods

<u>Focus Groups</u>

- 7-10 licensed drivers from one of 6 different cities participated in the focus groups.
- Various focus group techniques were used to evaluate existing and develop new messages.

<u>Laboratory Studies</u>

- 192 licensed drivers in six different cities participated.
- Various DMS messages were presented on computers and were evaluated by participants, in addition to having participants create their own messages for specific scenarios.

Findings

- The data collection activities resulted in general design recommendations in addition to recommendations for the wording and presentation of specific messages.
- Information related to road weather DMS messages covered hurricanes and flooding/high water.

Evaluation

- A combination of focus groups and laboratory studies was used for identifying key message design elements and evaluating basic yet important aspects of specific messages, such as comprehension.

General Comments

None.

Document Reference

Fayish, A. C., and Jovanis, P. P. (2004). Usability of statewide web-based roadway weather information system. *Transportation Research Record*, *1899*, 44-54.

Study Type	**Dissemination Methods**
Laboratory Study	Website

Weather Impacts/Conditions

General

Study Objectives

To conduct a usability study on a state-wide road weather web site.

General Approach

A usability study was conducted to assess how effective a state-wide web-based traveler information system was for conveying road and weather information to travelers.

Methods

- An assessment framework for the website was developed based on a literature review of traveler information needs.
- 98 travelers (college students) visited the website and provided ratings of several website attributes.
- Evaluation measures included:
  - Time to complete specific tasks.
  - Number of errors made.
  - Proportion of positive website evaluations to negative evaluations.
  - Number of times users got “sidetracked”.

Findings

- Key information needs as identified in the literature review include: Relevance, ease of use, ease of access, timeliness, coverage, and information accuracy.
- Identified design improvements included:
  - Better coverage of travel routes (e.g., regional boundaries didn’t match trips).
  - Desire to include trip origin and destination.
  - Inadequate ability to zoom in and out of maps/ legibility of map elements.
- This research also identified key information elements.

Evaluation

- This approach was effective in obtaining direct information about traveler information needs. It provided information about general website design principles, in addition to feedback about individual websites. However, the particular user population investigated likely limits the generalizability of the results.

General Comments

None.

Document Reference Golob, T. F., and Regan, A. C. (2002). *Trucking industry preferences for driver traveler information using wireless Internet-enabled devices* (Report No. UCI-ITS-LI-WP-02-5). Irvine, CA: Institute of Transportation Studies.	
Study Type Survey	**Dissemination Methods** Personal Electronic Device, Cellular Phone Messaging
Weather Impacts/Conditions General	
Study Objectives To understand how managers of trucking companies perceive the benefits of different types of information that could be delivered to drivers using Internet-enabled wireless devices.	
General Approach A phone survey was conducted with managers from trucking companies to identify the perceived benefits of Internet-based traveler information in the context of CVOs.	
Methods • Survey participants included managers from 712 trucking companies operating in California in 2001. • 3,438 companies were initially contacted, yielding a response rate of 24%. • Structural equation modeling was used to identify how perceptions of information usefulness were related to the operating characteristics of the companies.	
Findings • Weather information was one of the dimensions rated as being very important or fairly important by a majority of managers.	
Evaluation • The information provided by this approach is at a very general level and provides little if any information that is directly applicable to road weather information.	
General Comments None.	

Document Reference

Harder, K. A., and Bloomfield, J. R., (2008). *The effectiveness and safety of traffic and non-traffic related messages presented on changeable message signs—Phase II*. St. Paul: Minnesota Department of Transportation.

Study Type	**Dissemination Methods**
Laboratory Study, Survey	Dynamic Message Sign

Weather Impacts/Conditions

General

Study Objectives

To investigate the effectiveness and safety of traffic and non-traffic related messages presented on DMSs.

General Approach

A driving simulator was used to measure driver responses to various DMS messages, in combination with a survey approach to obtain driver opinions on a wider variety of message types.

Methods

Driving Simulator Study

- 120 drivers in young, middle-aged, and older age groups.
- Messages were presented on simulated DMSs and drivers responses to or their recollection of this information was measured.
- The clarity and complexity of DMS message information was varied.

Survey

- 120 of the laboratory study participants completed a survey after participating in the simulator study, to obtain their opinions regarding the value of the messages they encountered in addition to other DMS messages.

Findings

Driving Simulator Study

- Messages that provided simpler wording and/or more specific information were more effective.
- Speed measures were ambiguous.

Survey

- Different types of messages received different ratings with regard to how useful they are:
  - Traffic problem information was rated as very useful.
  - Road maintenance information was rated as very useful.
  - Travel time information was rated as useful.
  - Safety messages were rated somewhat negatively.

Evaluation

- The driving simulator study provided relatively limited information about specific DMS messages relative to the level of effort spent to collect this information. However, the survey did provide empirical validation of specific design approaches (i.e., simple/clear wording) and usable information about how useful drivers perceive various types of messages to be.

General Comments

None.

Document Reference ITS America. (2001). Roadway information service via a cellular phone. *Proceedings of the 8th World Congress on Intelligent Transport Systems [CD-ROM]*.	
Study Type Field Study	**Dissemination Methods** Website, Cellular Phone Messaging
Weather Impacts/Conditions General	
Study Objectives To evaluate usage of the web-based information system in Shikoku Island, Japan.	
General Approach There is no methodological information provided in the report other than information content provided and examples of textual weather information messages.	
Methods • See general approach.	
Findings • Includes comparison of access from a cellular phone and Internet. • Number of accesses. • Users' region. • Constitution of users.	
Evaluation • This report does not provide much useful information.	
General Comments None.	

Document Reference
Jonsson, M., Nass, C., Harris, H., and Takayama, L. (2005). Influence of hazard system accuracy on driving performance. *Proceedings of the 12th World Congress on Intelligent Transport Systems.*

Study Type	**Dissemination Methods**
Survey, Laboratory Study	Speech

Weather Impacts/Conditions
Fog

Study Objectives

To determine how speech message accuracy affects driver performance and attitudes.

General Approach

A driving simulator was used to measure driving performance and attitude in response to warning messages presented with varying levels of speech message accuracy.

Methods

- 60 drivers in a driving simulator received speech messages warning of potential road hazards, one of which included fog conditions ahead.
- Three levels of warning accuracy were provided: 100% accurate, 70% accurate, and no warning.
- Inaccurate messages warned of hazards that did not exist or were inconsistent with the actual hazard ahead.
- Three web-based questionnaires were given to determine drivers' attitudes about the in-vehicle information system (IVIS).

Findings

- Driving performance is negatively impacted with a reduction in the accuracy of information.
- Drivers' attitudes about the IVIS decreased proportionally with the level of information accuracy.

Evaluation

- The study was not weather specific; although a fog warning is included in the presented messages, the study focused on general warning messages. Nonetheless, the results are likely to be generalizable to weather messages.

General Comments

None.

Document Reference

Kajiya, Y., Suzuki, T., Matsuzawa, M., and Uemura, T. (2004). Study on effects and evaluation of winter road information. *Transportation Research Circular: Sixth International Symposium on Snow Removal and Ice Control Technology, E-C063*, 248-263. Retrieved September 19, 2008 from http://onlinepubs.trb.org/onlinepubs/circulars/ec063.pdf.

Study Type	**Dissemination Methods**
Survey, Focus Group	Website

Weather Impacts/Conditions

Winter Conditions

Study Objectives

To determine user needs for Internet-based road information and effects of providing road weather information on road traffic safety and driving comfort.

General Approach

Questionnaires were administered and a focus group conducted to determine how web-based weather information affects travel choice, traffic safety, and sense of security.

Methods

- A summer questionnaire was administered via website at the end of the summer to ascertain how information posted on the Northern Road Navi website was used, how useful it was, and how the information affected route choice.
- A winter questionnaire was conducted in February and March to determine the usefulness of mountain pass information in addition to the questions asked in the summer questionnaire.
- 111 respondents participated in a Contingent Valuation Method (CVM)-based survey (focus group) to determine driver needs for region-wide snowstorm information.

Findings

- 90% of respondents thought the Northern Road Navi website had a positive influence in enhancing safety and sense of security.
- Real-time information (mountain pass road images, weather forecasts, snow and frost duration) was valued as useful in enhancing safety and sense of security.
- On mountain passes, “road image” ranked highest in driver satisfaction; topographical information was viewed as needing the most improvement.
- Results are given related to how much participants were willing to pay for information.

Evaluation

- The report provides only general information about the questions asked in the questionnaire, with a few examples of questions asked. However, it does provide some useful information about content, dissemination method, and attitudes about how such an information system should be paid for.

General Comments

None.

Document Reference

Kajiya, Y., Wada, T., Kaneda, Y. (2002). Greater Sapporo ITS experimental project-smart Sapporo snow-info experiment. *Proceedings of the XIth International Winter Road Congress [CD-ROM]*.

Study Type	**Dissemination Methods**
Field Study, Survey	Website, Cellular Phone Messaging

Weather Impacts/Conditions

Winter Conditions

Study Objectives

To determine 1) the effectiveness and usefulness of sharing weather information among road administrators via website and 2) the effect on commuters' transportation modality by disseminating weather information to the public via cell phone.

General Approach

Two studies were conducted: 1) weather information was shared between road agency (e.g., roadwork, traffic regulation, snow removal operations, etc.) administrators via web pages, and 2) civilian participants received weather information email messages on their cell phones.

Methods

<u>Road Information Sharing</u>

- Road agency administrators shared information such as scheduled roadwork, current and scheduled traffic regulation, snow removal operations, and current/forecast weather conditions.
- A post-experiment survey was administered to determine agency opinions about usefulness of information sharing and effectiveness of dissemination method.

<u>Car Commuter Monitoring</u>

- Participants (monitors) received two email messages per day indicating temperature, snowfall, and road surface conditions.
- Similar information was presented on web pages that were accessible by cell phone.

Findings

The findings included these topics:

<u>Road Information Sharing</u>

- Survey results that suggest level of usefulness of weather information sharing and effectiveness of dissemination method.

<u>Car Commuter Monitoring</u>

- Relationships between snowfall/road surface conditions and commuting behavior.
- Self-reported level of satisfaction in the information and dissemination method.
- Information provision needs of car commuters.
- Future potential in behavior change of car commuters.
- Desirable devices and means of acquiring road weather information.

Evaluation

- The report provides little detail about the questionnaire that was administered to road agency administrators, and the results are quite broad, indicating only that web-based information was useful and that information sharing is useful.
- The Car Commuter Monitoring results contain some information that may be useful in determining methods that are effective at changing drivers' commuting choice in snow conditions. It is unclear whether these results are generalizable to other weather conditions.

General Comments

None.

Document Reference
Kajiya, Y., Yasuaki, M., and Matsushima, T. (2008). A study on the expression of winter road information and its effects on drivers' travel decision making. *Transportation Research Circular E-C126: Surface Transportation Weather; Snow and Ice Control*, 586-596. Retrieved September 9, 2008 from http://onlinepubs.trb.org/onlinepubs/circulars/ec126.pdf

Study Type	**Dissemination Methods**
Survey	Website

Weather Impacts/Conditions
Winter Conditions

Study Objectives
To determine the most appropriate way of providing information on visibility and surface conditions.

General Approach
A questionnaire was administered to 301 respondents to determine willingness to change travel behavior based on weather information methods in three forms.

Methods
- Respondents ranked on a 7 point scale whether they would change their travel behavior (e.g., "no change" through "cancel trip") based on three patterns of visibility and surface condition messages: 1) text only, 2) text + image, and 3) text + image + explanation.
- Respondents ranked on a 7 point scale the perceived level of hazard within a two dimensional matrix of visibility versus surface condition.

Findings
The study provides findings related to:
- Perceived importance of weather information.
- Influence of visibility on willingness to change travel behavior.
- Influence of surface condition on willingness to change travel behavior.

Evaluation
The report provides some insight into weather information content that may influence drivers' travel behavior and effectiveness of presentation methods. The results are based on subjective ratings.

General Comments
None.

Document Reference
Kolisetty, V. G. B., Iryo, T., Asakura, Y., and Kuroda, K. (2006). Effect of variable message signs on driver speed behavior on a section of expressway under adverse fog conditions - A driving simulator approach. *Journal of Advanced Transportation, 40*(1), 47-74.

Study Type	**Dissemination Methods**
Laboratory Study	Dynamic Message Sign

Weather Impacts/Conditions
Fog

Study Objectives
To determine the effectiveness of traffic advisory information for helping drivers to divert from potentially dangerous conditions.

General Approach
Participants viewed the same fog warning message on three successive DMS in a driving simulator scenario.

Methods
- 10 younger males (age 21 to 30) drove 8.5 km in a driving simulator scenario.
- DMSs with identical fog warning messages were presented at approximately 2 km intervals.
- A maintenance vehicle was placed 300-500 m ahead of the subject vehicle.

Findings
- DMSs appeared to have a positive effect on speed and speed reductions.

Evaluation
- The article provides information about the experiment methodologies, but with the exception of distance between signs, provides no information about the DMS messages, their content, or their presentation.

General Comments
None.

Document Reference

Kumar, M., and Strong, C. (2006). *Comparative evaluation of wind warning systems (Showcase Evaluation #15)*. Bozeman: Montana State University. Retrieved September 22, 2008 from http://www.wti.montana.edu/Projects.aspx?id=670e1499-468b-4676-b5d0-029f23c0603d.

Study Type	**Dissemination Methods**
Survey	Flip-up Sign, Dynamic Message Sign, Website

Weather Impacts/Conditions

High Wind

Study Objectives

To evaluate the Automated Wind Warning Systems (AWWS) regarding awareness of these systems and their perceived usefulness.

General Approach

A motorist survey was conducted with multiple-choice, ordinal ratings, and open-ended questions presented to assess various aspects of the AWWS.

Methods

- The survey was administered to 750 respondents; drivers of commercial or high-profile vehicles were targeted separately because of the high risk of overturning due to high wind.
- The survey solicited the following types of information:
  - Traveler characteristics.
  - Traveler perception of high winds as a hazard.
  - Traveler awareness of the AWWS.
  - System functionality and performance.
  - Demographic information.

Findings

- Results related to each of the target information categories above.
- Recommendations for additional dissemination methods and content were provided.

Evaluation

- This report contains some limited amount of information related to perceived usefulness and accuracy, presentation, and content, but it is not likely to be highly useful.

General Comments

The driver survey was only one component of the larger evaluation project.

Document Reference

Lappin, J. and Bottom, J. (2001). *Understanding and predicting traveler response to information: A literature review*. Cambridge, MA: Volpe National Transportation Systems Center.

Study Type	**Dissemination Methods**
Analytical Study	General

Weather Impacts/Conditions

General

Study Objectives

To conduct a review of published research regarding traveler response to real-time information at individual and network levels.

General Approach

A literature review was conducted to summarize published research into traveler response to real-time information at individual and network levels.

Methods

- Research sources included in the review were selected based on the following criteria:
  - Published in the last few years with relevant research or application results.
  - Publications providing summaries of long-term research or operational programs.
  - Selected older publications (10+ years) chosen for their historical interest.
- Annotated summaries were written for documents that provided summaries of the general approach and key findings.
- Approximately 175 research sources were summarized.

Findings

- The key findings were organized into 4 topics, including:
  - Traveler behavior without information.
  - Traveler behavior with information.
  - Network impacts of ATIS.
  - Modeling ATIS network impacts.

Evaluation

- This review provides a good integration of the available information at that time regarding traveler information needs and how they use information. This approach is relatively unstructured, so it difficult to assess how objectively different sources were considered. Overall, it is an effective and generally inexpensive method for extracting key findings and concepts for topics that have a large existing research literature base.

General Comments

None.

Document Reference
Martin, P. T., Perrin, J., Hansen, B., Meldrum, D. and Quitana, I. (2000). *Utah RWIS Traveler Information Evaluation* (UTRAC #99.4-5). Salt Lake City: University of Utah.

Study Type	**Dissemination Methods**
Survey	Multiple

Weather Impacts/Conditions
Winter Conditions

Study Objectives
To determine what weather-related information people want and need, and how they want to receive it.

General Approach
A survey was conducted among different traveler groups (commuters, truckers, recreational travelers, and long-distance travelers) to identify road weather information requirements and preferred dissemination methods.

Methods
- Participants were sought from four different groups: commuters, truckers, recreational travelers, and long-distance travelers (including out-of-state travel).
- Participants answered rating-scale questions.
- Data collection was conducted in April in Utah, with the intention capturing experiences from the previous winter.
- Commuters were recruited and surveyed using a telephone survey. Travelers were recruited at state "Welcome Centers" and locations of recreational attractions.
- Trucking companies were faxed copies of the survey and asked to return them.
- Approximately 270 surveys were completed, however, the final number is not provided in the report.

Findings
- DMS and radio are the most popular form of RWIS dissemination.
- Commercial radio and TV reports are popular among all but trucking industry dispatchers.
- Trucking industry dispatchers prefer the Internet.
- Some methods, such as telephone and paging services, or personal electronic devices received lower ratings, however, this may be due to drivers being unfamiliar with these technologies.
- Road condition information is the most preferred type of information, especially if it has impacts for their travel plans.
- Site-specific and corridor information is preferred over general weather information.

Evaluation
- This study provides very direct information about road-user information requirements. It also provides useful information about the benefits of specifically targeting different traveler groups in addition to strategies for accessing drivers from each group. The technology-specific findings, however, are likely to be out-of-date, given changes in technology-use patterns since the study was conducted.

General Comments
A copy of the questionnaire used is available in the appendix of this source.

Document Reference Motoda, Y., Takayama, T., Ikeda, T., Sano, Y., Abe, S., and Chiba, R. (2005). Assessment of a frozen road surface information system by public demonstration. *Proceedings of the 12th World Congress on Intelligent Transport Systems [CD-ROM]*.	
Study Type Survey	**Dissemination Methods** Website
Weather Impacts/Conditions Low Traction (Icy Roads)	
Study Objectives To evaluate a web-based icy-road information map display.	
General Approach A questionnaire was used to examine end-user reactions to road condition information presented as icons on a website. Information about road weather conditions was phoned-in to a central data-center by taxi drivers selected to participate in this study.	
Methods • A questionnaire web page was presented to web-site users and they were asked to provide their feedback about the website. Thirty-five completed responses were obtained from website users. • A questionnaire was provided to the taxi drivers that participated in the study. Sixty-two percent of the drivers provided responses (62%) • The relationship between website traffic and weather conditions was analyzed.	
Findings • Two-thirds of the website respondents gave the system positive evaluations. • Taxi drivers evaluated the system more positively than other website users. • There was a significant correlation between website traffic and low temperatures.	
Evaluation • The number of website responses was low and undermines the reliability of the findings. • The website traffic analysis, if conducted over a sufficiently long duration may be a useful approach although, in the current study, the instances of acute weather conditions was low.	
General Comments None.	

Document Reference Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCMSSR). (2002). *Weather information for surface transportation. National needs assessment report* (FCM-R18-2002). Silver Spring, MD: Author. Retrieved March 20, 2008 from http://www.ofcm.gov/wist_report/pdf/entire_wist.pdf.	
Study Type Expert Panel	**Dissemination Methods** TV, Radio

Weather Impacts/Conditions

Multiple/Comprehensive

Study Objectives

To summarizes current uses of weather information within the surface transportation area and provide an evaluation of current information versus current need as expressed by users across multiple surface transportation types. Contains statistical use data of current weather information for surface transportation. Current is represented as up to the year 2002.

General Approach

Surveys and interviews were used with transportation professionals to identify weather information needs at a national level for several transportation modes.

Methods

- A symposium of domain experts formed the starting point for identifying groups of weather information users.
- Letters of request and questionnaires were sent to surface transportation professionals in federal, state, and local governments, and in the commercial sector. Out of 700 questionnaires sent, 108 responses were received.
- In domains in which few responses were received, an additional round of questionnaires was sent out.
- In-person interviews were also conducted with select questionnaire participants.
- Follow-up surveys were sent out to expand on information obtained in the initial survey and interviews.

Findings

- This document provides a wide-ranging review of the needs derived from an evaluation of current weather information for a variety of surface transportation systems versus what is needed.

Evaluation

- This appears to be a useful and comprehensive approach for obtaining information about current practices or information needs from the transportation professional's perspective.

General Comments

None.

Document Reference
Osborne, L. F., Jr., Owens, M. S., and Hahn, B. C. (1998) Advanced transportation weather information system: Lessons learned. *Proceedings of the ITS American 8th Annual Meeting and Exposition.*

Study Type	**Dissemination Methods**
Field Study	511

Weather Impacts/Conditions
Multiple

Study Objectives
To present "lessons-learned" from an ATWIS demonstration project.

General Approach
See Methods.

Methods
- This paper does not provide any methodological details related to valuation of road user information needs.

Findings
- See Methods.

Evaluation
- See Methods.

General Comments
None.

Document Reference

Patten, M. L., Pribyl, O., and Goulias, K. G. (2003). *Evaluation of the Pennsylvania turnpike's Advanced Traveler Information System (ATIS) project, Phase III* (Report No. PTI 2004-01, Final Report). University Park: Pennsylvania Transportation Institute.

Study Type	**Dissemination Methods**
Survey	Dynamic Message Sign, Highway Advisory Radio, 511

Weather Impacts/Conditions

General

Study Objectives

To investigate how drivers use travel information and their awareness of applicable dissemination methods.

General Approach

Mail-back surveys were distributed to road users.

Methods

- The survey was distributed to 5,510 motorists and 3,584 truckers. Approximately 25% of drivers from each group responded.
- The survey asked drivers about their current trip on the Pennsylvania Turnpike.
- Drivers were asked to participate as they waited at toll booths to exit the Turnpike. Only a set proportion of drivers (based on the sampling plan) were approached each hour.
- Survey distribution locations were identified based on analysis of exit traffic characteristics, site visits and discussions with Turnpike personnel.

Findings

- The report provides many findings, but only those that are most relevant to road weather information use are described in this section.
- More than 50% of motorists sought travel information prior to their departure, which most commonly included traffic conditions, weather conditions, and route maps.
- While most were aware of DMSs, many fewer were aware of HAR (5%) and phone systems.
- Motorists thought it was very important to receive travel information during bad weather, when their travel time was critical, and while driving in congested conditions.

Evaluation

- Although this study is not specifically focused on road weather information, the methodological approach is useful and can be applied.
- Overall, this approach was effective for obtaining information from a large number of road users and focusing on a specific trip improved the validity of responses.

General Comments

None.

Document Reference

Peirce, S. and Lappin, J. (2003). *Acquisition of traveler information and its effects on travel choices: Evidence from a Seattle-area travel diary survey*. Retrieved March 21, 2008 from http://www.itsdocs.fhwa.dot.gov/JPODOCS//REPTS_TE/13813.html.

Study Type	**Dissemination Methods**
Survey	Comprehensive

Weather Impacts/Conditions

General

Study Objectives

To identify how travelers access travel information and how they incorporate this information into their travel choices.

General Approach

A travel-diary survey was used to record travel information use by participants over a 48-hour period.

Methods

- A travel-survey addition was included with a bi-annual, large-scale road-user survey conducted by the Puget Sound Regional Council in the Seattle Metro area.
- The survey contained a random sample of 1700 Seattle-area residents.
- The survey covered all travel modes, trip purposes, and information media, in addition to information about trip characteristics, road-user demographic, and experience with congestion.

Findings

- Basic travel/trip information was collected, including:
  - Trip purpose.
  - Use of traveler information services and motivations for doing so.
  - Impacts of traveler information in travel plans.

Evaluation

- The approach used provided specific and representative data on use of traveler information systems. The quality was very high and informative, but it required “piggy-backing” data collection on a more comprehensive large-scale survey.

General Comments

None.

Document Reference

Stanley, L. M., Kelly, M. J., and Lassacher, S. (2005). Driver performance while interacting with the 511 travel information system in urban and rural traffic. *Proceedings of Driving Assessment 2005: 3rd International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*.

Study Type	**Dissemination Methods**
Laboratory Study	511

Weather Impacts/Conditions

General

Study Objectives

To measure the impacts of using a 511 system (hand-held and hands-free access) on driving performance.

General Approach

A driving simulator was used to measure driving performance and responses to traffic conflicts while drivers access a 511 system (both hand-held and hands-free access).

Methods

- Participants were 36 licensed drivers between the ages of 18 and 63 (mean age = 31) that were cellular telephone users.
- Participants were screened for simulator sickness, trained to drive the simulator using progressively more complex scenarios, and then trained to use the state DOTs 511 phone system.
- Participants were divided into 3 phone groups that were equalized as best as possible based on participant demographics. The groups included hand-held, hands-free, and control conditions.
- Drivers encountered pre-programmed traffic conflicts that required evasive responses.
- Drivers used voice commands to navigate the 511 system.

Findings

- Primary driving measures (e.g., lane keeping and speed control) were not impacted by 511 use.
- Responses to traffic conflicts that required immediate attention were degraded by 511 use.
- Drivers had significantly more collisions in both 511 conditions than in the control condition.
- Authors concluded that situational awareness is degraded by 511 use.

Evaluation

- This study provides a basic comparison of driving performance under different 511 use conditions. It is difficult to directly extrapolate the safety/crash results to real-world performance because of inherent differences in how drivers approach simulated driving. However, the basic conclusion that situational awareness is degraded by 511 use is likely to be a useful caution. The approach taken in this study is highly specific to a particular implementation and dissemination method, and it requires a high-fidelity implementation of the dissemination method.

General Comments

None.

Document Reference

Ullman, B. R., Dudek, C. L., Trout, N. D., and Schoeneman, S. K. (2005). *Amber alert, disaster response and evacuation, planned special events, adverse weather and environmental conditions, and other messages for display on dynamic message signs.* (Report No. FHWA/TX-06/0-4023-4. Report 0-4023-4). College Station: Texas Transportation Institute.

Study Type	**Dissemination Methods**
Focus Group, Laboratory Study	Dynamic Message Sign

Weather Impacts/Conditions

Flooding; Hurricane

Study Objectives

To identify driver information needs related to AMBER alert, disaster response (flood, hurricane, terrorist attack), adverse weather, and special event messages.

General Approach

Focus group studies were conducted in six cities in Texas to obtain driver needs and attitudes related to various messages to be displayed on DMS. Results from the focus group studies were used as the basis for more extensive laboratory studies.

Methods

<u>Focus Groups</u>

- Five different techniques (listing, rating, ranking, recall, and building test messages) were used during focus groups, consisting of a total of 54 participants in six cities in Texas, to identify appropriate message content and presentation related to the various conditions.

<u>Laboratory experiments</u>

- Laboratory experiments were administered using several different methods of interface including laptop computer programs, maps, card selection, and driving simulator.
- Map studies were used to identify effective terms for roadway elements and situations during flooding conditions.
- Participants examined pairs or groupings of messages and stated which format of the message they preferred.
- In laptop computer studies, participants were shown simulated sign messages to determine appropriate descriptors in Ozone warning messages.

Findings

- This report includes recommendations for content, wording, and presentation of messages for DMS related to weather and other events.

Evaluation

- This report presents detailed methodologies. The study applies to both specific conditions as well as general DMS design principles.

General Comments

None.

APPENDIX C.
ROAD WEATHER INFORMATION QUESTIONNAIRE

Road Weather Information Questionnaire

Thank you for taking the time to complete this questionnaire. This research is being conducted on behalf of the Federal Highway Administration by the Battelle Memorial Institute, which is a non-profit scientific research institute. The objective of this questionnaire is to obtain a better understanding of travelers' interest in information about road weather conditions.
Please note that all your answers are completely voluntary and you are not required to answer a question if you do not want to.

1. Which age category do you fit in?

1	**2**	**3**	**4**	**5**
18-25	26-40	41-55	55-65	Over 65

2. Are you a male or female? ____

3. What is the purpose of the trip you are *currently* taking?

- ☐ Recreational/vacation travel
- ☐ Daily commute to work
- ☐ Personal/family travel
- ☐ Work-related travel/delivery that is not a commute
- ☐ Other ___________________________________

4. How long do you expect your current trip to take from start to finish?

- ☐ Less than 4 hours
- ☐ 4 – 8 hours
- ☐ More than 8 hours
- ☐ Multiple Days

5. For most of your current trip are you:

- ☐ Driving alone?
- ☐ The driver with one or more passengers?
- ☐ A passenger?

Road Weather Information Questions

We use the term "road-weather conditions" to mean information about the conditions of roads that you are/will be driving on or may be considering driving on during an upcoming trip. The specific road conditions refer to factors that may affect the safety of a road (e.g., snow or ice that cause poor traction) or how long it takes to drive on the road. For example, if it causes traffic back-ups or requires slower driving.
Also, this applies to information you obtain before you leave (including the previous day) or information you obtain during your trips (e.g., from roadside signs).

6. How often, if ever, do you seek out road condition information under moderate weather events (e.g., rain, fog, etc)?

1	2	3	4	5
Never	Rarely, when conditions occur	Occasionally, when conditions occur	Most times, when conditions occur	Always, when conditions occur

7. How often, if ever, do you seek out road condition information under more severe weather events (e.g., snow on the ground, heavy rains, wind storms, etc)?

1	2	3	4	5
Never	Rarely, when conditions occur	Occasionally, when conditions occur	Most times, when conditions occur	Always, when conditions occur

8. In the past year, have you encountered a weather event in which you were concerned about the condition of the roads that you or someone in your household might encounter while driving?

- ☐ Yes
- ☐ *No, please skip to Question 14 on page C-6*

9. What was the weather event? *(please check all that apply)*

- ☐ Snow
- ☐ Heavy Rain
- ☐ High Winds
- ☐ Freezing conditions/Icy roads
- ☐ Flooding/high water
- ☐ Other (Please describe) ______________________

10. What specific road conditions were you concerned about? ***(please check all that apply)***

- ☐ Road closures or impassable roads
- ☐ Flooding or standing water on roads
- ☐ Delays in starting trip
- ☐ Slippery conditions
- ☐ Getting stranded
- ☐ Very slow travel speed or stop-and-go traffic conditions
- ☐ Other (Please describe) ____

11. What was your *primary* source of information about road weather conditions? *(please check only one response)*

- ☐ Road Weather Information Kiosks
- ☐ Highway Advisory Radio (HAR)
- ☐ Changeable Message Signs by the roadside
- ☐ State DOT or other Road Weather Information Web site (e.g., weather.com)
- ☐ GPS navigation devices
- ☐ Cell phone road-weather applications
- ☐ 511 telephone information services
- ☐ Regular TV or Radio weather forecasts
- ☐ Other (Please describe) ____

12. How reliable was the information you obtained?

1	**2**	**3**	**4**	**5**
Not Reliable at All	Somewhat Reliable	Often Reliable	Mostly Reliable	Very Reliable

13. Did you make any of the following changes to your travel plans based on the information you obtained? *(please check all that apply)*

- ☐ Took a different route
- ☐ Drove a different vehicle or took a different type of transportation (e.g., bus)
- ☐ Drove with extra caution
- ☐ Cancelled or postponed your trip
- ☐ Changed your departure time to avoid weather problems
- ☐ Left earlier to make up for longer travel times
- ☐ Did not change plans

14. How important do you think the following types of road-weather information are?

14.a. Information indicating that the roads you will be driving on are slippery or hazardous

1	2	3	4	5
Not Important at all	Somewhat unimportant	Neither important or unimportant	Somewhat Important	Very Important

14.b. Information indicating that the roads you intended on taking are closed or impassable

1	2	3	4	5
Not Important at all	Somewhat unimportant	Neither important or unimportant	Somewhat Important	Very Important

14.c. Information indicating that there are weather-related travel delays or slow-downs on the roads you will be driving

1	2	3	4	5
Not Important at all	Somewhat unimportant	Neither important or unimportant	Somewhat Important	Very Important

14.d. Information indicating that there is or will be flooding around the roads you will be driving

1	2	3	4	5
Not Important at all	Somewhat unimportant	Neither important or unimportant	Somewhat Important	Very Important

14.e. Information indicating that there is the potential for getting stranded on the roads you will be driving

1	2	3	4	5
Not Important at all	Somewhat unimportant	Neither important or unimportant	Somewhat Important	Very Important

15. How useful do you think it is to obtain road condition information at the following points prior or during your trip?

15.a. Trip planning (a few days before to the day before)

1	2	3	4	5
Not Useful at All	Somewhat Useful	Often Useful	Mostly Useful	Very Useful

15.b. Prior to leaving (within one hour of your departure time)

1	2	3	4	5
Not Useful at All	Somewhat Useful	Often Useful	Mostly Useful	Very Useful

15.c. At a stopping point during your trip (e.g., at a rest area, gas station, or travel information center)

1	2	3	4	5
Not Useful at All	Somewhat Useful	Often Useful	Mostly Useful	Very Useful

15.d. While you are driving from (e.g., from a roadside sign or device like a cell phone or radio)

1	2	3	4	5
Not Useful at All	Somewhat Useful	Often Useful	Mostly Useful	Very Useful

16. The following boxes describe sources of road weather information. Please tell if you are aware of these sources for *road condition* information and if you have ever used them before.

Road Weather Information Kiosks

These allow you to look up road weather information using a touch screen. They sometimes are found at Rest Areas or Traveler Information Centers.

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

Highway Advisory Radio (HAR)

This is a radio station dedicated to traffic information.

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

Changeable Message Signs by the roadside

These signs are sometimes found by the roadside and contain important traffic-related messages on that can be changed (they are also known as Variable Message Signs or Dynamic Message Signs).

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

State DOT or other Road Weather Information Web site (e.g., www.weather.com)

A dedicated road weather web site, typically provided by the State Department of Transportation. It is often separate from a traffic congestion map.

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

GPS navigation devices

This is a GPS navigation or other related device in which road weather information is automatically updated for the road that you are traveling on.

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

Cell phone road-weather applications

This is a portable cellular-enabled device that you could use to look up road weather conditions.

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

511 telephone information services

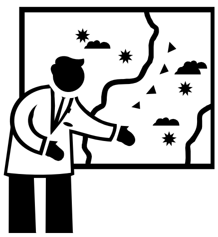
Traveler information service with road-weather information available by calling "5-1-1".

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No



Note: This figure is not the original graphic used in the survey. The original was a picture of a local news-weather forecaster presenting traffic congestion information on a city map.

Regular TV or Radio weather forecasts

Traditional traffic and/or weather forecasts available on local broadcast television or radio stations.

Were you aware that you could use this source to get information about road weather conditions?

☐ Yes
☐ No

Have you ever used this source to obtain weather condition information for roads that you will drive on?

☐ Yes
☐ No

17. Are there any improvements that you would like to see regarding what road weather information is provided to you, or how it is provided?

___

___

___

___

APPENDIX D.
LITERATURE SYNTHESIS SUMMARIES

<table>
<tr><th>1. What types and sources of weather information are used by drivers in making travel decisions?</th><th></th></tr>
<tr><td>2-day travel diaries in which respondents recorded basic information about each trip they made
Caveats:
- Participants were urban commuters and based on traffic reports not weather reports
- Technology information is likely outdated
- Transit users were intentionally overrepresented in the sample
Findings:
- 12% of respondents consulted traveler information in the 2-day period
- The most common dissemination methods were:
o On-route radio (56% of trips where info was sought)
o Pre-trip radio (22%)
o TV news broadcasts (13%)
o Traffic websites (6%)
o Transit websites (5%)</td><td>Pierce & Lappin (2003)</td></tr>
<tr><td>Mail-back survey of motorists and truckers distributed at a turnpike toll-booth exit
Caveats:
- Technology information is likely outdated
- Study examined travel information in general and not just weather reports
Findings:
- The most common dissemination methods were:
o TV/radio (47%)
o Internet (26.9%)
o Map or atlas (26.7%)
o Cell phone (1.8%)
o Telephone (1.6%)
- Percentage of motorists rating each dissemination method as very or extremely useful:
o Commercial radio (70.0%)
o DMS (67.6%)
o HAR (45.2%)
o Kiosks (43.5%)
o Cell phones (33.5%)
o TV (27.6%)
o Internet (17.6%)
o Telephone (15.1%)</td><td>Patten, Pribyl, & Goulias (2003)</td></tr>
</table>

Phone survey of different types of drivers, including: commuters, truckers, recreational travelers, and travelers *Caveats:* - Technology information is likely outdated *Findings:* - Different commuter types had different preferred methods for accessing information - The rank order of dissemination methods across traveler types: DMS, Radio, HAR, TV, websites, phone, in-vehicle navigation system, email, CB radio, Kiosks, pagers - Recreational travelers were more likely to use kiosks than other groups - Truckers used the phone and websites more often than other groups	Martin et al. (2000)
2. What types of adjustments do travelers make in light of weather information?	
A survey was used to investigated commuter travel behavior in response to traffic information *Caveats:* - Participants were urban freeway commuters so travel decisions were limited - Decisions are based on congestion delays – weather conditions may affect decision-making in a different way *Findings:* Based on traffic information: - 40% were willing to change both departure time and route (35% of these respondents report changing trip based on weather information, vs. 89% for congestion, 86% for traffic reports, 44% for time pressure) - 23% were unwilling to change departure time - 21% were willing to change their route en-route - 16% were willing to make time, mode, or route changes prior to leaving home	Haselkorn & Barfield (1990)
A survey was used to collect data on propensity to divert and related factors from downtown Chicago auto commuters *Caveat*: - Usage patterns are likely to be outdated - Participants were urban commuters and based on traffic reports not weather reports *Findings*: - 60% of travelers changed their route or departure time based on radio traffic reports - Drivers indicated low levels of satisfaction with traffic reports that suggested alternative routes	Khattak, Schofer, & Koppelman (1992)

Mail-back questionnaires regarding socio-economic characteristics, travel characteristics, use of radio traffic reports and use of DMS messages *Caveats*: - Usage patterns are likely to be outdated - Participants were urban commuters *Findings*: - Drivers were more likely to make route adjustments based on radio information with short trips	Emmerink et al. (1996)
2-day travel diaries in which respondents recorded basic information about each trip they made *Caveats:* - Participants were urban commuters and based on traffic reports not weather reports - Technology information is likely outdated - Transit users were intentionally overrepresented in the sample *Findings:* - 37% of trips for which traveler information was consulted resulted in some change in travel behavior (1% of total trips recorded) - Most typical changes (on subset of trips in which travel info was consulted) o Departure time (13%) o Route (11%) o Travel mode (1%)	Pierce & Lappin (2003)
Telephone survey of residence in a populated transportation corridor, which included automobile commuters, transit commuters, automobile non-commuters, and transit non-commuters *Caveat*: - Participants were urban commuters receiving traffic congestion information *Findings*: - A significant portion of respondents (between 18 and 52 percent, depending on mode and trip purpose) do not divert because of travel information; - The propensity to adjust pre-trip decisions is highest for commuters; - Receipt of travel information from radio reports (as opposed to television and telephone) increases the frequency of pre-trip changes for automobile and transit commuters, and automobile non-commuters; - Individual with longer reported travel times in severe traffic conditions are more likely to change their departure times and routes; - Non-commuters and radio listeners are most likely to cancel their trips in response to information. - Radio information was the source that was the most likely to lead to trip changes	Khattak et al. (1999)

Survey and model of commuter departure time choice *Caveats*: - Participants were Japanese commuters, so attitudes and their importance may differ based on cultural norms *Findings*: - Commuters appear to be risk-adverse regarding travel time - Most commuters rely on expectations about travel time to avoid arriving "too early" or "too late" - Importance of arrival time is lower for commuters with flexible work start times	Fujii & Kitamura (2000)
3. What are the safety implications of these adjustments?	
No data	
4. When can drivers make the best use of information (e.g., trip planning, en-route, etc.)?	
Mail-back questionnaires regarding socio-economic characteristics, travel characteristics, use of radio traffic reports and use of DMS messages *Caveats*: - Usage patterns are likely to be outdated - Participants were urban commuters *Findings:* - 15% of motorists sought weather condition information prior to departing - Weather condition information prior to leaving most often by motorists between the ages of 46-60, and by vacation and business travelers	Emmerink et al. (1996)
Mail-back survey of motorists and truckers distributed at a turnpike toll-booth exit *Caveats:* - Technology information is likely outdated - Study examined travel information in general and not just weather reports - Categories in findings below are modified from original question to match Task 4 categories *Findings:* - Percentage of respondents rating information access as very or extremely important by trips stage: o Before starting trip (52.3%) o On-route (47.8%) o Stopped on-route (27.7%)	Patten, Pribyl, & Goulias (2003)
Phone survey of different types of drivers, including: commuters, truckers, recreational travelers, and travelers *Caveats:* - Technology information is likely outdated	Martin et al. (2000)

Findings: - Time when different travelers preferred to receive information: o Commuters and recreational travelers preferred getting their information less than 1 hr before and en-route o Travelers preferred information at all intervals, with 1-2 days prior and en-route the most common o Truckers from any time from 3 hours before to en-route	
5. How soon before a weather event is expected to occur, or how soon prior to leaving for their trip, do travelers want and need information?	
Phone survey of different types of drivers, including: commuters, truckers, recreational travelers, and travelers *Caveats:* - Technology information is likely outdated *Findings:* - Provides graphs showing when different types drivers preferred receiving weather information relative to the start of their trip, and - Graphs showing where, relative to the location of the weather event, different driver types prefer to receive weather information	Martin et al. (2000)
6. What types of weather conditions require weather information to preserve driver safety before they get on the road or while they are on the road?	
No data	
7. What kind of improvements in weather information do travelers need (previously question #4)?	
No data	
8. How might more or improved weather information be used?	
No data	
9. What is the value of more or improved weather information?	
No data	
10. Which Dissemination Methods do different types of travelers prefer?	
Mail-back questionnaires regarding socio-economic characteristics, travel characteristics, use of radio traffic reports and use of DMS messages *Caveat*: - Usage patterns are likely to be outdated - Participants were urban commuters receiving traffic congestion information *Findings*: - Business travelers were more likely to change their routes than commuters based on DMS traffic information	Emmerink et al. (1996)

Mail-back survey of vehicle commuters surveyed about AM peak drive into downtown Chicago *Caveat*: - Usage patterns are likely to be outdated - Participants were urban commuters receiving traffic congestion information *Findings*: - Males and high income earners were more likely to use travel reports to modify their travel decisions	Khattak, Schofer, & Koppelman (1992)
2-day travel diaries in which respondents recorded basic information about each trip they made *Caveats:* - Participants were urban commuters and based on traffic reports not weather reports - Technology information is likely outdated - Transit users were intentionally overrepresented in the sample *Findings:* - Males and females consulted travel information at approximately the same rate - Males were slightly more likely to consult websites than females, but there were no other significant differences in dissemination method use	Pierce & Lappin (2003)
11. To what extent is drivers' dissemination method preference based on lack of knowledge of what is available?	
Survey conducted to gather information about motorists behavior and decision processes as they relate to the design and delivery of motorist information *Caveat*: - Usage patterns are likely to be outdated - Participants were urban freeway commuters *Findings*: - Commercial Radio: 98% of drivers have ever used this source (55% thought the info was very useful) - VMS: 53% used, (7% thought very useful) - HAR: 44% used, (5% thought very useful) - TV: 29% used, (3% thought very useful) - Phone: 8% used, (1% thought very useful)	Haselkorn &Barefield (1990)
12. How do driver demographics/characteristics vary based on preference for different dissemination approaches?	
Redundant with question 10	

13. What factors determine which dissemination method drivers will use to obtain road weather information?	
Mail-back questionnaires regarding socio-economic characteristics, travel characteristics, use of radio traffic reports and use of DMS messages *Caveat*: - Usage patterns are likely to be outdated - Participants were urban commuters receiving traffic congestion information *Findings*: - Factors associated with using traffic information from radio include: long trip duration, more than one route available, business trip, male less than 45 years old	Emmerink et al. (1996)
14. How important is trust in the accuracy and reliability of information, and what are the best ways to promote this trust?	
Mail-back survey of vehicle commuters surveyed about AM peak drive into downtown Chicago *Caveat*: - Usage patterns are likely to be outdated - Participants were urban commuters *Findings*: - Travelers that perceived traffic reports as more accurate were more likely to rely on this information when considering route changes - Travelers that perceived traffic reports as more accurate were more likely change their departure time based on this information	Khattak, Schofer, & Koppelman (1992)
Driving simulator study that examined (1) the effects of information accuracy, and (2) familiarity of the driving environment on subjective measures related to trust *Caveat*: - Conclusions are based on driving simulator environment using real-time traffic information - Participants were urban commuters receiving traffic congestion information *Findings*: - 100 percent accurate information yielded the best driver performance and subjective opinion - 71 percent accurate information remains acceptable and useful and drivers are willing to tolerate some error in a simulated ATIS. Drivers will still use information in this condition - When information accuracy was at 43 percent, driver performance and opinion suffered - Inaccurate traffic information was more harmful in a familiar setting. Since drivers have greater self-confidence in familiar settings, they are more critical of ATIS messages and hold it to a higher standard of acceptability	Kantowiz et al. (1996)

Driving simulator study looking at the effect of accuracy of hazard and weather information on driving performance and trust Caveat: - Hazard warnings were mixed in with weather warnings and accuracy level was based on both types of warnings Findings: - Participant ratings of system trustworthiness, authoritativeness, and "qualification" of system were significantly higher in the 100% accuracy condition than the 70% condition - Perceived trustworthiness of the system was also positively related to drivers overall rating of the car	Jonsson, Nass, Harris, & Takayama (2005)
15. What phrasing (advisory or control) should be used in various situations?	
Mail-back survey of vehicle commuters surveyed about AM peak drive into downtown Chicago *Caveat*: - Usage patterns are likely to be outdated - Participants were urban commuters receiving traffic congestion information *Findings*: - Driver satisfaction was lower for traffic reports that provide prescriptive suggestions (similar to control phrasing) for alternative routes - Authors suggest that descriptive information (e.g., degree of congestion on a route and estimates of incident duration) may be better accepted, although data are not reported	Khattak, Schofer, & Koppelman (1992)
Traveler response case studies collected as part of a survey *Caveat*: - Participants were urban commuters receiving traffic congestion information *Findings*: - For drivers that changed travel route while on the road, the rate of switching increased as a function of the elaborateness (level of detail, care in justification) of the guidance message	Polydoropoulou & Ben-Akiva (1999)
16. Are visual or audio effects (e.g., sound clip of thunderclap) useful for communicating the degree of severity?	
Comprehensive literature review about best modality for information motorist-related information *Caveats*: - Most of the research reviewed was not directly related to weather information or traveler information systems - The evaluation took into account technological limitations (e.g., voice synthesis fidelity) that no longer apply	Hulse et al. (1998)

Findings: Use auditory presentation if: - The message is simple - The message is short - The message will not be referred to later - The message deals with events in time - The message calls for immediate action - The visual system of the person is overburdened - The receiving location is too bright, or dark adaptation integrity is necessary - The person's job requires continual movement from place to place Use visual presentation if: - The message is complex - The message is long - The message will be referred to later - The message deals with location in space - The message does not call for immediate action - The auditory system of the person is overburdened - The receiving location is too noisy - The person's job allows the person to remain in one place Other findings: - Limit complex information to 7 or less chunks pieces of information - Continuous information should not be displayed using auditory channels since it leads to driver annoyance - Report provides a Sensory Modality design tool that has some aspects that are relevant to weather message design	
Survey-based evaluation of road condition presentation format for websites including: text only, text + image of conditions, and text + image + description of condition impacts on safety *Caveats:* - Study participants were Japanese, so there may be behavioral differences related to safety cultural perspectives on safety *Findings:* - For low-visibility conditions: Text + image led to a higher percentage of drivers indicating they would choose more cautious travel behavior than text alone - For low-traction: Text + image was not different from text alone, but adding the description increased percentage choosing cautious travel behavior	Kajiya, Yasuaki, & Matsushima(2008)

Survey of travelers that used a DOT Weather information website *Caveats:* - Sample population was a subset of people already viewing the website *Findings:* - Features that were the rated as being the most useful and most frequently accessed by website visitors included: o Weather condition information o Mountain-pass conditions o Traffic cameras o Road conditions – temperatures o Highway conditions o Statewide weather map	Boon & Cluett (2002)
17. When there are more information units than can be displayed, what information units should be displayed?	
Comprehensive literature review about best modality for information motorist-related information. - Limit complex information to 7 or less chunks pieces of information	Hulse et al. (1998)
18. How can the safety impacts of a driver obtaining road weather information while on the road be minimized?	
Driving performance while accessing 511 information was measured in a driving simulator. *Caveat:* - The number of crashes was relatively high, suggesting that drivers likely did not take the driving task as seriously as they would normal driving *Findings:* - Basic driving functions (lane & speed maintenance) were unaffected during 511 access - Ability to respond to hazardous situation was reduced when 511 information was accessed with either a hands-free or hand-held cell phone - Recall of scenario events (proxy for situation awareness) was lower in the 511 access conditions	Kelly, Stanley, & Lassacher (2005)
19. For each combination of Weather Condition/Impact and Dissemination Method, what information /specific messages should be presented and how should it be displayed?	
This is addressed as part of Task 5	

APPENDIX E. TRAVELER INFORMATION NEEDS AND TUTORIALS

This appendix contains supplementary information from the design tool. The first section is material related to optional Step 2a in the design tool which includes information about traveler information needs. The second section consists of the tutorials which provide background information on a travelers' use of road weather information.

TRAVELER INFORMATION NEEDS

This section provides additional recommendations about the type of information that travelers are likely to need when making certain travel decisions. The guidance in this section can be used to identify information elements that can be included in a road weather message so that it better matches what information travelers are looking for when they seek out road weather information.

Each travel decision is discussed separately using the following layout:

- **Introduction**: Defines how the travel decision applies, and provides information about the situations involved.
- **Information Needs Summary Table**: A table that outlines key traveler information needs based on the actions that travelers might take in a situation. This also includes information about which groups of travelers are likely to use certain information, and caveats associated with using certain dissemination methods to communicate with travelers, if they apply.
- **Discussion**: This section elaborates on key elements in the Information Needs Summary Table.
- **Short Text/Visual Message Examples**: This section provides example DMS messages related to a travel decision. Also included in these examples is a list of the key DMS message elements based on the Dudek (2004) guidelines. These elements make it easier to apply a basic message to different road weather conditions. Table E-2 below provides definitions of these message elements.
- **Example Features or Information for Open Format Text/Visual Messages**: A table listing useful website display features that address traveler information needs.
- **Auditory Message Examples**: Example 511 or HAR messages that cover some of the traveler information needs for each decision.

The recommendations about traveler information needs in this chapter are provided in separate sections organized according to travel decisions. Table E-1 below indicates on which page the recommendations for each travel decision can be found. The pages that immediately follow the table below provide some background information about how some of the recommendation information about traveler information needs were identified.

Table E-1. Traveler Information Needs Look-up Table showing where to find information about each travel decision.

Travel Decision	Page
Expect delays	Travel Decision 1, page E-3
Change route	Travel Decision 2, page E-6
Change travel mode	Travel Decision 3, page E-10
Drive with caution	Travel Decision 4, page E-13
Change driving behavior	Travel Decision 5, page E-16
Make safety-related preparations	Travel Decision 6, page E-20
Cancel trip	Travel Decision 7, page E-24

Table E-2. Key DMS message element definitions (adapted from Dudek, 2004).

Message Element	Definition
Weather Descriptor*	Informs the traveler of the unusual situation
Location*	Informs the traveler of the location of the unusual situation
Lanes Closed (Blocked)	Gives specific information about which lanes or exit ramps are closed or blocked
Closure Descriptor	Used in place of the *Weather Descriptor* when all lanes on the facility or exit ramp are closed
Location of Closure	Used in place of the *Location* and states the location of the freeway closure
Effect on Travel	Informs the traveler of the severity of the situation and helps the traveler decide if a diversion is appropriate
Audience for Action	Used when the *Action* message component applies to a specific group of travelers rather than all travelers who see the DMS
Action	Tells the traveler what to do
Good Reason for Following the Action	Gives the traveler confidence that following the advice on the DMS will result in safer travel and/or significant time savings

- * The names of these message elements were changed to apply more generally to weather conditions.

TRAVEL DECISION 1: EXPECT DELAYS

Introduction

This travel decision applies when it will take drivers longer than normal to travel on certain roadways. Many travelers, especially commuters, are averse to travel delays and will alter their travel plans to avoid delays (e.g., Haselkorn & Barfield, 1990). There appears to be a lower bound to what most travelers consider a delay, which seems to be around 10 to 15 minutes longer than normal travel (Ullman, Dudek, and Balke, 1992; Huchingson and Dudek, 1979).

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Plan for delays	All	Length of delay Location of delay	None
Leave later	Travelers with flexible schedules (e.g., not typically commuters or CVO drivers)	Need to know that conditions are expected to improve	En-route methods are unsuitable because the trip has started
Leave earlier	All	Information must be available early enough for travelers to arrange to leave earlier	En-route methods are unsuitable because the trip has started

Discussion

The primary action associated with this travel decision is planning for delays because it is available to all drivers during most of their travel. This action involves travelers adjusting their schedules to take into account the delay. Tutorial 1 discusses the frequency of traveler trip time changes. Travelers can most readily use this information before they depart, however, it is still useful en-route if they can phone ahead to warn others of their delays. Tutorial 2 discusses the suitability of making this travel decision at various trip stages. The key information is the duration of the delay, since it will determine the traveler's course of action. For short delays, travelers may decide that their plans are not affected in important ways. For example, Ullman et al. found that it wasn't until delay times reached 15 minutes that 50% of drivers asked would consider a diversion to another route. Another notable finding is that the phrasing of a delay message influenced driver willingness to divert to another route. In particular, using "save X min" lead drivers to consider diversions sooner than "X min delay" (Ullman, Dudek, and Balke, 1992; Huchingson and Dudek, 1979).

The options related to changing departure time are sub-sets of the "plan for delays" action and typically apply to travelers who receive the information prior to leaving and that also have the flexibility to change their schedule. Note that drivers will make decisions related to planning for delays in other weather-related situations, since traffic disruptions are a common impact associated with several types of weather events. Apart from traffic-flow disruptions, another situation in which a delay is unavoidable is if drivers cannot reach a destination using certain roads, and travelers are required to reroute, which will likely add to travel time.

Expect Delays: Short Text/Visual Message Examples

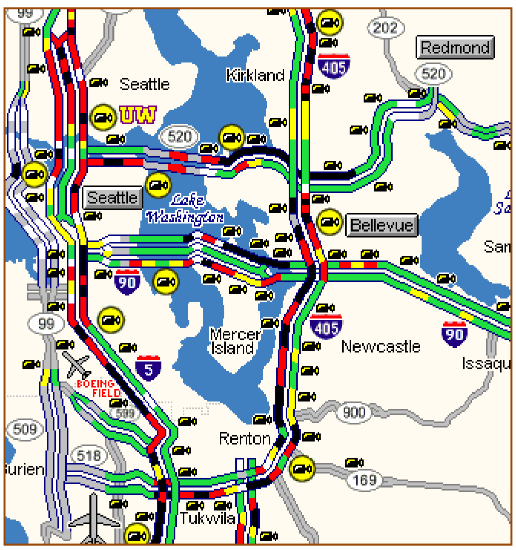
For a short text/visual message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

	Message Elements	
	Baseline Message	**Message Without Recommended Action**
Line 1	Weather Descriptor	Weather Descriptor
Line 2	Action	Location*
Line 3	Delay Information (Good Reason for Following the Action)	Delay Information (Effect on Travel)
Example	WATER ON ROAD TAKE US-23 SAVE 20 MIN	WATER ON ROAD AT EXIT 12 20 MIN DELAY

* Optional line

Expect Delays: Example Features or Information for Open Format Text/Visual Messages

Website or other open-format features or content that provide information that supports traveler decision making are shown in the table below.

Useful Display Features	Information Elements
Traffic Map 	• Location and magnitude of delays (colored roads) • Location of information (non-gray roads) • Location of traffic cameras
Traffic Camera 	• Camera image allows drivers to see the congestion levels and conditions on the road • Time and location of camera image
Other Text Information	• How long the weather events causing the delay conditions are expected to last • Description of the weather event so that drivers can infer the above information based on what they know of the weather event

Expect Delays: Auditory Message Example

An example HAR or 511 auditory message that is consistent with the auditory message guidelines provided in this report is shown below for this travel decision.

- Attention southbound Interstate 5 traffic
- There are snow flurries between Washington State Route 599 and Washington State Route 518
- Expect congestion, and delays greater than 20 minutes

Source: Adapted from HAR Message Development Guide

TRAVEL DECISION 2: CHANGE ROUTE

Introduction

This travel decision most importantly applies when travelers cannot reach a destination using their intended route or taking an intended route is highly inadvisable. In the context of road weather conditions, this can involve the closure of roads, such as mountain passes, or roadways that are at risk of flooding. However, the decision to change routes is a common decision by certain types of drivers (Tutorial 1), such as those familiar with the road network, and these drivers will make this decision in other situations than just road closures.

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Get off current route	All drivers, but non-local or non-commuter drivers may have difficulty re-routing on their own	• Route is impassible or closed • Location of problem, if it is restricted to a specific area or location	Not ideal on roadways frequented by recreational or out-of-area travelers
Take specific alternate route	All drivers	• Route is impassible or closed • Options for alternative routes	None

Discussion

The primary way in which drivers would likely use this information is if they cannot reach their destination using certain routes and have to find an alternative route. The key information in this case is that the route is impassible or closed, and this information should be part of any messages providing route-change information. To the extent that it is feasible, providing additional information about suitable ways to exit closed or impassible routes and information about alternative routes helps drivers unfamiliar with the road network. The table below provides message examples for communicating diversions to specific other routes (from Dudek, 2004). The messages are divided into normal diversions and pre-established diversion routes such as detours. Note that Dudek (2004) also recommends that for diversion routes that are not pre-established, the DMS operator should know the conditions on the alternate route before advising travelers to divert to that route, which generally requires electronic and/or human surveillance. Tutorial 2 discusses the suitability of making this travel decision at various trip stages.

Another useful message element is information about where the closed or affected area is located. This is helpful even if there is no diversion information because familiar drivers may be able to find their own suitable alternative routes, or reject alternatives that may still be in the affected regions. Also, travelers unfamiliar with the area would at least have the option of using other methods, (e.g., maps) to identify the problem location and find suitable alternative routes.

Example messages for route changes on specified other routes for normal diversions and pre-established diversions.

Diversion Condition	Action Elements
Normal Diversion	• EXIT AND USE [highway name, street name, route number] • EXIT AT [highway name, street name, route number]/ USE [highway name, street name, route number] • TAKE [exit ramp name] EXIT • TAKE [exit ramp name] EXIT/ USE [highway name, street name, route number] • TAKE EXIT [exit ramp number] • TAKE EXIT [exit ramp number]/ USE [highway name, street name, route number]

Diversion Condition	Action Elements
	• TAKE [highway name, street name, route number] • TAKE [highway name, street name, route number]/ USE [highway name, street name, route number] • TAKE NEXT EXIT • TAKE NEXT [number] EXITS • USE [highway name, street name, route number] • TUNE RADIO TO [number] AM (or FM)
Pre-established Diversion	• EXIT AND FOLLOW DETOUR • EXIT AND FOLLOW SIGNS • EXIT AT [highway name, street name, route number]/ FOLLOW DETOUR • EXIT AT [highway name, street name, route number]/ FOLLOW SIGNS • TAKE [exit ramp name] EXIT/ FOLLOW DETOUR • TAKE [exit ramp name] EXIT/ FOLLOW SIGNS • TAKE EXIT [exit ramp number]/ FOLLOW DETOUR • TAKE EXIT [exit ramp number]/ FOLLOW SIGNS • TAKE [highway name, street name, route number]/ FOLLOW DETOUR • TAKE [highway name, street name, route number]/ FOLLOW SIGNS • TAKE NEXT EXIT
Each verb used in the above diversion action elements has a slightly different meaning. When creating original diversion messages, keep in mind the following definitions (from Dudek, 2004): • USE: a route that carries travelers to their destination (which may be their original route) • TAKE: a directive to begin the first "leg" of the route (which should connect with the current route) • FOLLOW: traveler will be guided by other signs along the route • EXIT: sometimes used as a verb with a highway name, street name, or route number (not an exit number) • GO: not used in DMS messages, but sometimes used in HAR messages	

Change Route: Short Text/Visual Message Examples

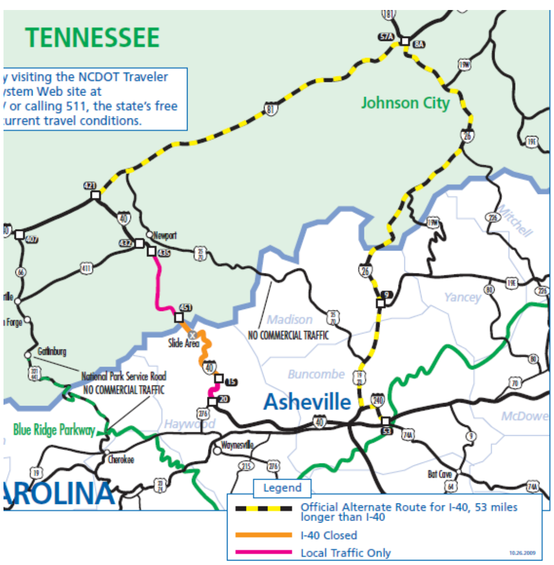
Communicating that a route is impassable using a DMS can be more challenging for weather conditions than typical road-closure situations because the causes may be less localized than usual. For example, heavy snow may affect a road and the nearby alternative routes to a similar degree, whereas crash or roadwork-related closures would be localized to a single road.

For a short message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

	Message Elements	
	Diversion to Specific Route	**Diversion to Non-Specific Route**
Line 1	Location of Closure	Location of Closure
Line 2	Weather Descriptor	Weather Descriptor
Line 3	Action	Action
Example	I-5 CLOSED AHEAD DEEP WATER TAKE NEXT EXIT	I-5 CLOSED AHEAD DEEP WATER USE OTHER ROUTES

Change Route: Example Features or Information for Open Format Text/Visual Messages

Drivers can benefit from map-based information showing the affected roads or region, in addition to alternative routes that are unaffected or less affected by the weather event.

<table>
<tr><th>Useful Display Features</th><th>Information Elements</th></tr>
<tr><td>Route Map

</td><td>Location/extent of problem or closure
Color coded major roads affected
Visual depiction of alternative roads that are unaffected or less affected by the conditions</td></tr>
<tr><td>Text Information
DUE TO A ROCK SLIDE, I-40 IS CLOSED IN BOTH DIRECTIONS BETWEEN EXIT 20 (U.S. 276), 24 MILES WEST OF ASHEVILLE, IN NORTH CAROLINA AND EXIT 421 (I-81 INTERCHANGE), EAST OF KNOXVILLE IN TENNESSEE.

Travelers can still reach Western North Carolina. The road is not expected to reopen for several months.

<u>Official Detour:</u> Motorists traveling on I-40 West are advised to take Exit 538, I-240 West. Follow I-240 West to Exit 4A, I-26 West. Follow I-26 West (a North Carolina Scenic Highway) to I-81 South. Take I-81 South and follow back to I-40, Mile Marker 421, in Tennessee. This route is 53 miles longer than I-40.

For a map of detour routes and the affected road closure, please click here.</td><td>Location of affected area
Text description of alternate routes
Ways to exit the closed route</td></tr>
</table>

Change Route: Auditory Message Examples

An example HAR or 511 auditory message that is consistent with the auditory message guidelines provided in this report is shown below for this travel decision.

- Attention Eastbound Interstate 10 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- There is major flooding ahead
- To avoid major delay, exit at Ronstadt and take the following route:
- Turn right on Ronstadt and continue to Boardwalk
- Then left on Boardwalk and continue to Wilshire
- Then turn left again on Wilshire and proceed back to Interstate 10
- [Please drive safely OR We regret any inconvenience]

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

The following message is more suitable for HAR usage than 511 due to its length and listing of alternate telephone numbers.

Example: Diversion onto a Specific Route

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- Interstate 90 West is closed to thru-traffic between (City A) and (City B)
- Snow and high winds have caused drifting snow and limited visibility
- Westbound traffic headed for (City C) must take alternate route, US 40
- All Westbound Interstate 90 traffic must exit at the next interchange and detour onto alternate route, US 40 West
- Signs on the detour route will guide you to (City C) and points west
- Roads and travel information on current conditions and on other alternate routes in the area may be received by calling (telephone no. XXX-XXXX in City C). Again, the (City C) phone number is XXX-XXXX.

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

TRAVEL DECISION 3: CHANGE TRAVEL MODE

Introduction

This involves the decision to switch from one travel mode to another. The primary reason for making this decision is if one mode is significantly delayed or non-operational (e.g., transit disruptions). However, some drivers (Tutorial 1) who have a flexible schedule, may also change from driving to other modes based on weather conditions (e.g., biking on a sunny day, getting a bus ticket to go skiing for the day if it is snowing). Additionally, the decision to switch from driving to transit may also be a component of campaigns to reduce driving, such as ozone reduction days.

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Switch from transit to other modes like driving	Primarily transit users and commuters who use transit some of the time	• Weather impacts on transit operations (delayed or cancelled) • Weather conditions make taking transit undesirable	Transit websites may be the primary information source
Switch from other modes to transit	Older drivers and drivers with flexible schedules	• Weather conditions are favorable for transit • Road weather conditions are unfavorable for driving	Regular weather forecasts may be the primary information source
Switch between other non-transit modes	"Fair weather" bicyclists and commuters	• Weather conditions are favorable for other modes	Regular weather forecasts may be the primary information source

Discussion

One implementation issue with regard to supporting the travel decision to switch away from transit (because of delays or cancelations) is whether a road weather message is the most appropriate place for this information. If travelers are concerned about transit operations, a logical place to obtain that information is from a transit-related information source (e.g., transit website). Providing information about transit disruptions alongside road weather information maybe more of a convenience to travelers (i.e., they can get all their road-related weather/travel information from a single source). However, this requires that the transit information be accurate and timely, so a better way to provide this convenience is via a link to transit information. Note that a DMS message is not useful because travelers will not view that message until after their decision is made, however, other short text messages alerting of transit disruptions are still appropriate. Tutorial 2 provides additional guidance regarding the trip stage at which it is most suitable to convey mode change information.

In contrast, the decision to switch from driving to transit is one that can be made more easily if transit information is available in the same place as road weather information. In this case, drivers could see that road weather conditions may be unfavorable, but that transit operations are on schedule/still operating and decide to forgo driving. Another version of this travel decision may apply under fair weather conditions. In this case, some travelers may decide to avoid driving and bicycle or walk to enjoy the nice weather. Note that regular weather forecasts are probably more likely to be the primary source of information for travelers making this decision, since they focus more on future weather conditions.

A special case of this travel decision involves switching away from driving based on transportation management campaigns, such as those designed to reduce ozone levels. This type of message is different in nature than most road weather information, unless travel restrictions are based on real-time conditions. Otherwise, the key information in this case is just a reminder to drivers familiar with the program about implementation details, such as when certain vehicle groups are not supposed to drive. On its own, this type of message is insufficient to communicate the details of the campaign, but participating drivers can be assumed to be already familiar with these details.

Change Travel Mode: Short Text/Visual Message Example

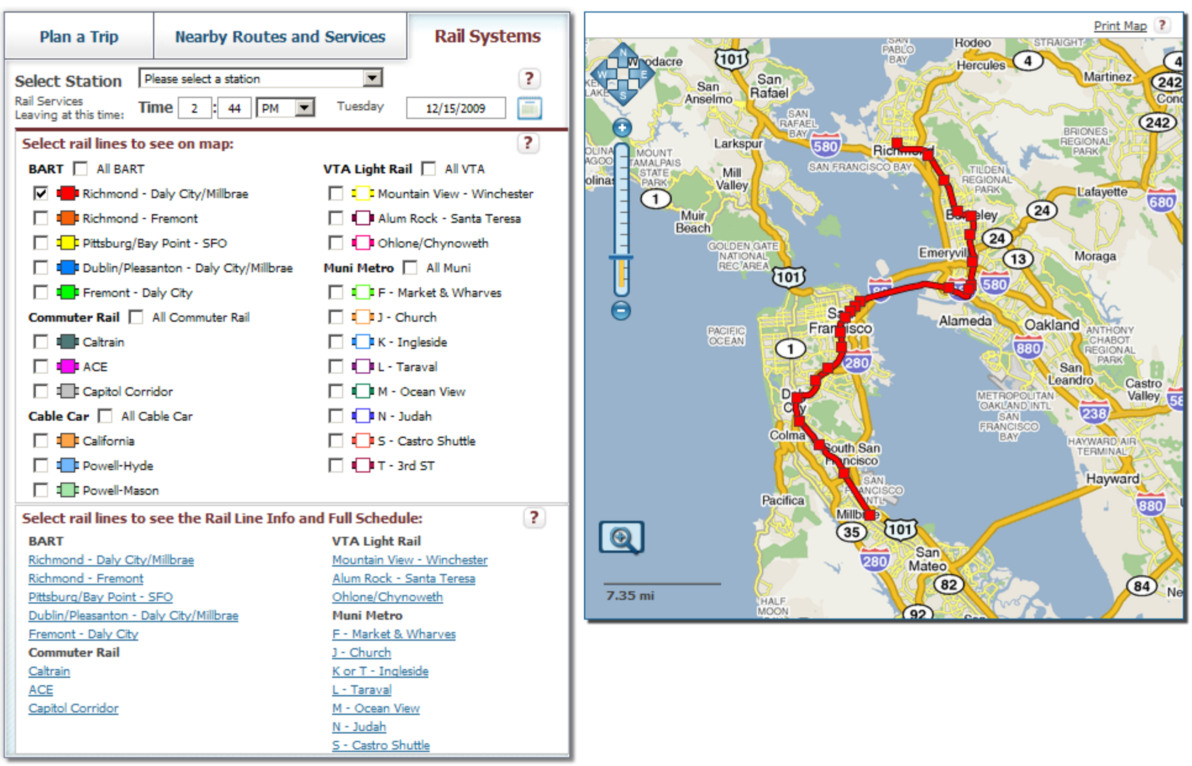
For a short message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

	Message Elements	
	Phase 1	**Phase 2**
Line 1	Weather Descriptor	Audience
Line 2	Location	Recommended Action
Line 3	Effect on Travel	
Example	THICK FOG ON BAY BRIDGE 45 MIN DELAY	SAN FRANCISCO TAKE BART

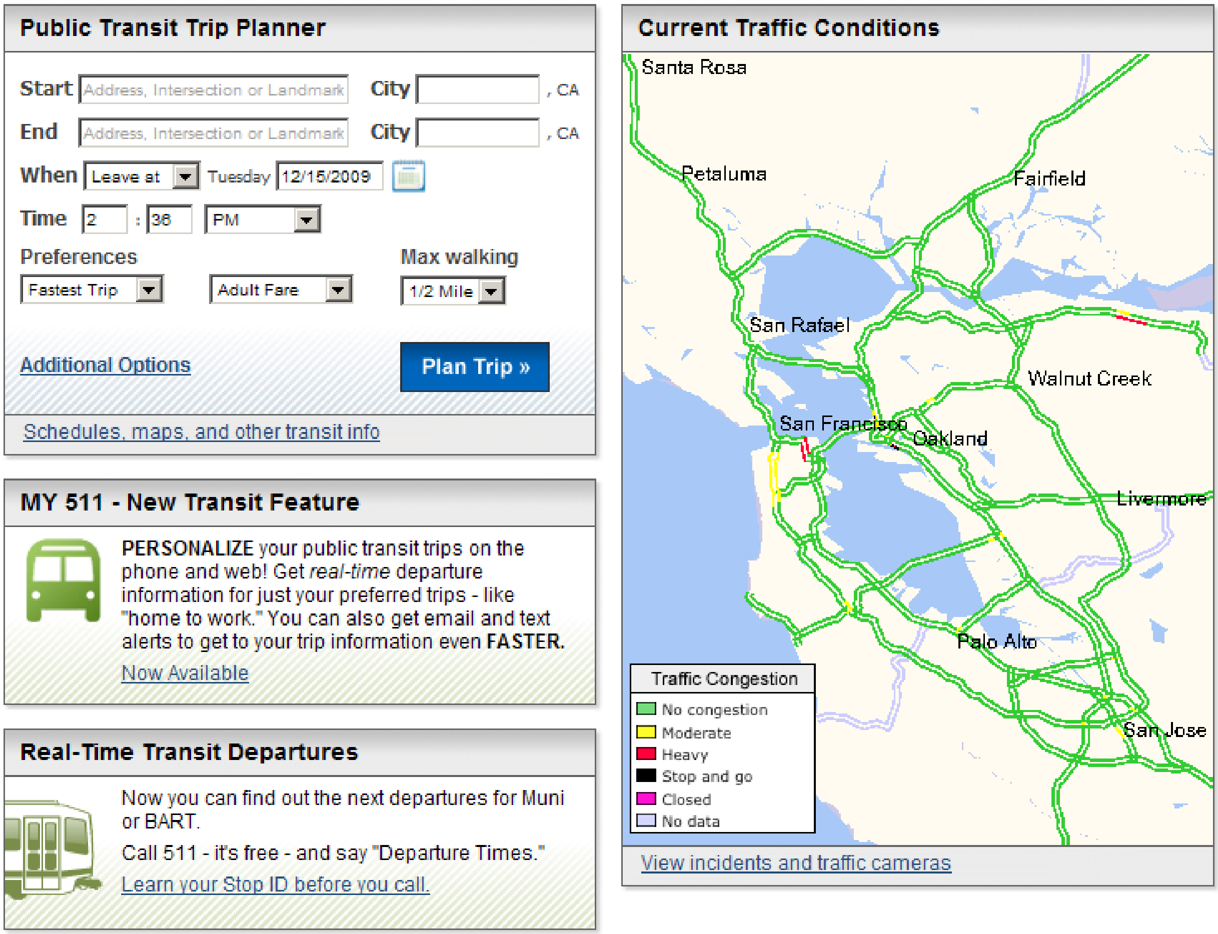
Change Travel Mode: Example Features or Information for Open Format Text/Visual Messages

Website or other open-format features or content that provide information that supports traveler decision making are shown in the table below.

Useful Display Features	Information Elements
Transit Map	• Route map for available transit resources so drivers can determine the feasibility of changing modes



Useful Display Features	Information Elements
Text Information	• Links to transit websites • Box displaying transit information such as departure times, any delays • Transit schedules



Change Travel Mode: Auditory Examples

An example HAR or 511 auditory message that is consistent with the auditory message guidelines provided in this report is shown below for this travel decision.

- Attention westbound California State Route 24 traffic
- Thick fog has caused severely reduced visibility on the Bay Bridge
- Expect traffic congestion and delays in travel time
- To avoid a 45 minute delay, take Bay Area Rapid Transit

TRAVEL DECISION 4: DRIVE WITH CAUTION

Introduction

This travel decision is one that drivers should make when the road weather conditions are such that driving in a normal way (e.g., at full speed, not paying full attention to the road, etc.) may pose a safety risk. The primary reason to provide this information is to alert drivers to be more careful, or to pay greater attention to their driving environment. Note that the overall tone of this type of message is as an advisory or informational warning, not one that directs or "commands" drivers to act in a specific way. The frequency of this travel adjustment is shown in Tutorial 1.

This travel decision recommendation is similar to the one on changing driver behavior (Travel Decision 5); however, the key differences are that the current recommendation involves 1) road weather conditions that are likely to be less severe, and 2) the primary adjustments in behavior required from drivers are simply extra care and attention to driving with regard to certain hazard conditions.

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Drive with greater alertness / caution	All drivers	• Driving conditions are not normal and require caution or attention • Specific information about hazards that may not be easily perceived (e.g., black ice) • Location information if it is not directly implied in the dissemination method (e.g., DMS location)	Most effective when information is communicated in vicinity of hazard (Tutorial 2)

Discussion

A key assumption with communicating this type of information is that the simple alerting of drivers to conditions is sufficient, and that responsibility for taking greater care resides with individual drivers. It is not currently known how well drivers comply with these types of advisory messages, and it is likely that some drivers will ignore this type of information.

An important use of this type of advisory information is to warn drivers of potentially hazardous conditions that are not immediately apparent to drivers, such as black ice, icy roads, high winds, etc. Following this logic, if there are two different weather conditions that warrant the same "use caution" type message, the condition that is less obvious to drivers should be given priority. For example, it is more useful for a driver to receive a warning about black ice that they cannot see, than fog, which drivers can easily see for themselves.

Location information is also important in this type of message if it is not directly implied by the dissemination method. If the hazardous conditions are not near the DMS, location information should be provided if possible. On a DMS, the caution information will be interpreted as being on the road ahead. If this is not the case, then more specific location information should be provided. This is important, because if drivers' experiences do not match the advisory information, then drivers may perceive this type of information as unreliable and be more likely to disregard this information in the future. See the guideline on communicating geographic extent (Guideline 27) for additional information.

Note that Guideline 01 recommends avoiding the use of the word "caution" in a short text message because drivers may not always interpret the word's meaning properly. However, when used as described in the current recommendation, the word "caution" is acceptable because the phrase specifically applies to the situation and it describes precisely what drivers should do.

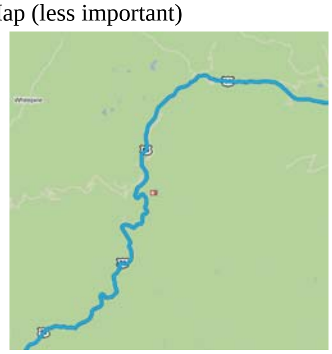
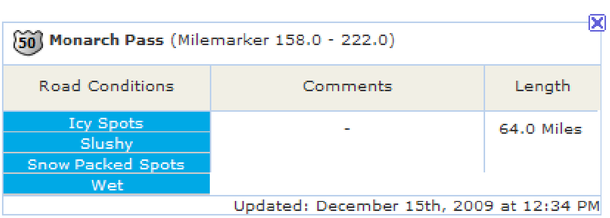
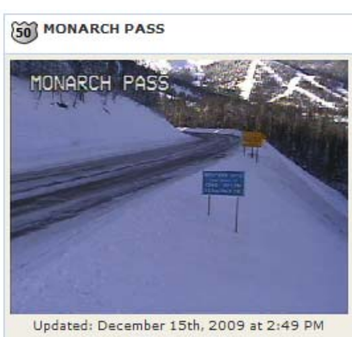
Drive with Caution: Short Text/Visual Message Examples

For a short message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

	Message Elements	
	Baseline Message	**Message Without Recommended Action**
Line 1	Weather Descriptor	Weather Descriptor
Line 2	Location	Location
Line 3	Action	
Example	ICY ROADS NEXT 4 MILES USE CAUTION	ICY ROADS NEXT 4 MILES

Drive with Caution: Example Features or Information for Open Format Text/Visual Messages

Website or other open-format features or content that provide information that supports traveler decision making are shown in the table below.

<table>
<tr><th>Useful Display Features</th><th>Information Elements</th></tr>
<tr><td>Route or Area Map (less important)
</td><td>Location/extent of problem
Color coded major roads or areas affected by weather event</td></tr>
<tr><td>Text Information

50 Monarch Pass (Milemarker 158.0 - 222.0)
<table><tr><th>Road Conditions</th><th>Comments</th><th>Length</th></tr><tr><td>Icy Spots
Slushy
Snow Packed Spots
Wet</td><td>-</td><td>64.0 Miles</td></tr></table>
Updated: December 15th, 2009 at 12:34 PM</td><td>Location of affected area
Text description of recommended actions</td></tr>
<tr><td>Camera

</td><td>Camera image allows drivers to get a better sense of the severity of the conditions (note: some conditions such as black ice will not appear in a camera image)</td></tr>
</table>

Drive with Caution: Auditory Message Examples

The following messages are more suitable for HAR usage than 511 due to their length.

Example: Be Alert for Black Ice

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- Be alert of ice on bridges, overpasses, and areas shaded by trees. During periods of freezing and thawing, a coat of black ice is formed. The surface of the ice will melt first leaving a film of water.
- Remember – Surfaces are more slippery at 30 degrees than at zero degrees.

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

Example: Watch Out for Snow Plows

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- Be alert for slow vehicles removing snow from the Interstate
- They will have flashing amber lights or you may see only a cloud of snow.
- When passing a snow plow, drive slowly and watch out for the plow blade. Always give the plow the right of way. They are clearing the road for your safety and convenience.

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

Example: Be Alert for General Hazardous Conditions

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- Be alert for hazardous driving conditions ahead. There are strong and gusty crosswinds as well as blowing snow and icy spots in isolated areas on Interstate 90 West to (City B).
- Conditions may vary throughout this section.
- The posted speed limits will be enforced.

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

TRAVEL DECISION 5: CHANGE DRIVING BEHAVIOR

Introduction

This decision is similar to the one involving driving with caution, however, it is typically related to more severe conditions and involves providing information about specific actions that drivers should take to improve their driving safety. A key element is that there is a specific action or change in driving behavior (e.g., driving below a certain speed) that would be reasonably expected to reduce crash risks under those conditions. The safety implications of presenting road weather information are discussed in Tutorial 4.

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Drive slower / below a specified speed	All	• Driving at normal speed is unsafe • Recommended safe speed	Most effective when information is communicated in vicinity of hazard
Get out of a lane	All	• There is a hazard in a particular lane that drivers should leave in order to avoid	
Expect high winds	CVO drivers, RV drivers, etc.	• High wind conditions	
Leave greater headway	All	• There is low traction or leaving greater headway is safer	
Turn on headlamps	All	• Visibility is reduced or can be improved by turning on headlamps	

Discussion

All of the available traveler actions listed above have the same basic nature, but are specifically related to different types of road weather hazards. Related to this, it is important that the recommended action be viewed as a reasonable action to take given the driving hazard (e.g., turn on lights or increase headway with reduced visibility). This affects the credibility of the message and drivers are less likely to comply with advisories if they do not perceive the information as being helpful. There is some existing evidence about driver compliance with these types of messages (mostly from variable speed messages); however, the findings are mixed (Robinson, 2000). In particular, some studies report little to no change in speed behavior, whereas others report more success; these latter instances were often part of a large program that included elements such as increased enforcement. Therefore, it is difficult to attribute the effectiveness of messages to the road information alone. Also, it is uncertain to what extent these findings about reduced speed apply to other recommended actions, such as turning on headlamps. On the one hand, these other actions are typically not associated with enforcement, which could lead to lower compliance than speed reductions. On the other hand, they do not have the same undesirable effects on travel (e.g., longer travel time), so compliance could be better in this regard.

Location information is also important in this type of message if it is not directly implied by the dissemination method. If the hazardous conditions are not near the DMS, location information should be provided if possible. On a DMS, the caution information will be interpreted as being on the road ahead. If it this not the case, then more specific location information should be provided. This is important, because if drivers' experiences do not match the advisory information, then the driver may perceive this type of information as unreliable and be more likely to disregard this information in the future. See the guideline on communicating geographic extent (Guideline 27) for additional information.

The table below provides a list of existing DMS message examples in use in several states that show different message variations for communicating to drivers that they should alter their driving behavior.

Example DMS messages related to changing driver behavior.

Weather Condition	Example Messages
Blowing Dust	• BLOWING DUST AHEAD SLOW TURN ON LIGHTS
Blowing Snow	• BLOWING SNOW AHEAD SLOW TURN ON LIGHTS
Bridge or Road Frost	• BLACK ICE REDUCE SPEED • ICE ON BRIDGE SLOW • ICE ON ROAD AHEAD SLOW TURN ON LIGHTS • WATCH FOR ICE/ICE NEXT ## MILES
Flooding	• FLOODING AHEAD REDUCE SPEED • IF WATER ON RD/TURN AROUND/DON’T DROWN • ROAD FLOODED SLOW • WATER CROSSING ROAD SLOW
Fog	• DENSE FOG AHEAD SLOW TURN ON LIGHTS • MAX ## MPH IN AREAS OF FOG • SPEED LIMIT ## MPH IN AREAS OF FOG
General	• RIGHT LANES BLOCKED USE LEFT LANE • TURN OFF CRUISE CONTROL
High Winds	• ADVISE NO LIGHT TRAILERS DUE TO STRONG WINDS • ADVISE NO LIGHT TRAILERS GUSTS ##+ MPH • HIGH WIND ADVISORY/NEXT ## MILES/CAMPERS AND TRAILER/NOT ADVISED • HIGH WIND WARNING/NEXT ## MILES/CAMPERS AND TRAILERS/PROHIBITED • HIGH WINDS CLOSED TO SEMIS
Moderate to Heavy Snow	• SNOW BLOWERS AHEAD DO NOT PASS • SNOW PLOW AHEAD DO NOT PASS • SNOW REMOVAL EQUIPMENT NEXT ## MILES TRUCKS USE RIGHT LANE ONLY
Reduce Speed	• ## MPH MAX • ## MPH MAX SPEED • ADVISE ## MPH • ADVISE ## MPH MAX • ADVISE ## MPH MAX SAFE SPEED • ADVISE ## MPH MAX SPEED • ADVISE MAX SAFE SPEED ## MPH • MAX ## MPH • MAX SPEED ## MPH • PLEASE SLOW DOWN • REDUCE SPEED • REDUCE SPEED ## MPH • SLOW DOWN • SLOW DOWN ## MPH • SPEED LIMIT ## MPH ON DOWN GRADE
Trailers	• ADVISE NO LIGHT OR EMPTY TRAILERS • ADVISE NO LIGHT OR EMPTY TRLRS • ADVISE NO LIGHT TRAILERS
Wet Roads	• ADVISE ## MPH WHEN WET • AVOID WET ROAD CRASHES

Change Driving Behavior: Short Text/Visual Message Examples

For a short message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

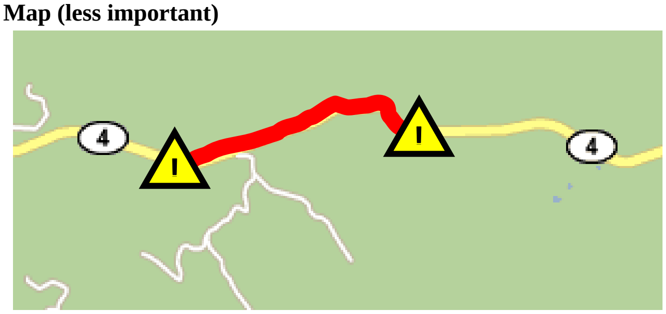
	Message Elements	
	Baseline Message	**Baseline Message**
Line 1	Weather Descriptor	Weather Descriptor
Line 2	Location	Location
Line 3	Action	Action
Example	BLOWING SNOW PAST EXIT 12 REDUCE SPEED 35 MPH	DENSE FOG PAST ROUTE 46 TURN ON LIGHTS

2-phase Message with an Audience

	Message Elements	
	Phase 1	**Phase 2**
Line 1	Weather Descriptor	Audience
Line 2	Location	Recommended Action
Line 3		
Example	HIGH WIND ADVISORY NEXT 4 MILES	CAMPERS / TRAILERS ADVISE 30 MPH MAX

Change Driving Behavior: Example Features or Information for Open Format Text/Visual Messages

Website or other open-format features or content that provide information that supports traveler decision making are shown in the table below.

Useful Display Features	**Information Elements**
Route or Area Map (less important) 	• Location/extent of problem • Color coded major roads or areas affected
Text Information **Difficult Driving Conditions - NM 4** **New Mexico 4 Northbound and Southbound from mile marker 33 to mile marker 46.** Difficult driving conditions exist on NM 4, mile marker 33-46 (La Cueva to the Los Alamos County Line). Road is icy in shaded areas. Visibility is good. Please driver with extra caution and reduce your speed. Last updated: 2009-12-15 13:43:10 MST	• Location of affected area • Text description of road weather • Recommended action

Useful Display Features	Information Elements
Camera  	• Camera image allows drivers to get a better sense of the severity of the conditions and provides more reason for drivers to change their behavior

Change Driving Behavior: Auditory Message Examples

Multiple example auditory messages that are consistent with the auditory message guidelines provided in this report are shown below for this travel decision. The following messages are more suitable for HAR usage than 511 due to their length and references to the radio service.

Example: Advice for Large Vehicles

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- There are strong and gusty crosswinds on Interstate 90 West between (City A) and (City B).
- These winds may be hazardous and cause a loss of control of large vehicles.
- Drivers pulling trailers or driving recreational vehicles are advised to wait in (City A) until the winds subside.

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

Example: Leave Greater Headway

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- At this time of year motorists traveling through (State) should adjust to the bad weather by driving slower. Allow a greater distance between your vehicle and the one ahead.
- Leave at least two car lengths between vehicles or one car length for each 10 MPH of speed.
- Remember it takes longer to stop

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

TRAVEL DECISION 6: MAKE SAFETY-RELATED PREPARATIONS

Introduction

This travel decision applies to situations in which drivers are either required or would be better off making certain preparations before departing or traveling through a specific area. A common example of this situation is when drivers need to put on chains before entering a mountain pass or other snowbound area. However, this can also pertain to a less obvious situation, such as if there is the potential of getting stranded in severe weather conditions or extreme temperatures.

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Bring tire chains or high-traction tires	Long distance, CVO drivers, and recreational travelers	• Types of vehicles that must use chains, etc. • Information about where drivers can stop	En-route dissemination methods may be less effective for travelers who haven't brought required equipment
Bring supplies	Long distance and recreational travelers	• That there is a risk of being stranded en-route • Conditions are extreme	Mostly applies to dissemination methods available where they can make preparations
Cancel trip Take alternative route	Long distance and recreational travelers	• That there is a risk of being stranded en-route • Conditions are extreme	None

Discussion

Communicating the need for some vehicles to equip chains or take other related measures is relatively simple. It is common practice in most areas, and phrases like "chains required" etc. are likely to be clearly understood by most drivers familiar with winter conditions. Providing additional information that there is a specific location available to equip chains may also prevent some drivers from stopping at an unintended location to do, however, the likely existence of a chain-up area near an advisory message is also commonly understood by many drivers.

Drivers who do not regularly carry chains and associated equipment require advance warning of chain requirements prior to departure, or early enough to be able to change routes if they believe that it is unsafe or they will not be permitted to continue without chains (see Tutorial 2 for guidance regarding the timing of this information).

Communicating the risk of being stranded or the need to bring supplies is more complicated. Since a route is not closed, drivers are likely to assume that the roads are passable, and some drivers may decide to brave difficult conditions. It is unclear whether or not the recommended action should be to avoid an area in this situation. Once an area is closed the travel decision becomes Travel Decision 7: Cancel Trip. Nevertheless, the information communicated should imply that conditions are severe and that there is a risk of becoming stranded without assistance. Information elements that are consistent with this point include:

- Conditions are severe or extreme
- Other drivers are getting stranded/stuck or there is a chance of being stuck
- Emergency services are not operating in an area because of weather conditions
- Drivers are recommended to travel with appropriate supplies and a reliable vehicle, including:
    - Appropriate clothing for the weather conditions
    - Blankets during winter stranding conditions
    - Food/drinks for longer trips
    - Drivers should avoid getting on the road if their vehicle has mechanical problems or is unreliable
    - Drivers should make sure they have more than enough gas in the tank for their trip
    - Other safeguards for unforeseen conditions

Make Safety-Related Preparations: Short Text/Visual Message Examples

For a short message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

	Message Elements	
	Baseline Message	**Baseline Message**
Line 1	Action	Action
Line 2		Location
Line 3	Location	
Example	CARRY CHAINS OR TRACTION TIRES 5 MILES AHEAD	CHAINS REQUIRED ON US-50

Other Examples

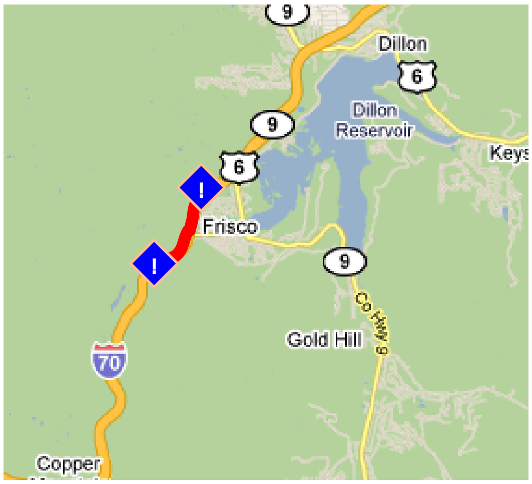
	Message Elements	
Line 1	Weather Descriptor	Descriptor
Line 2	Location	Location
Line 3	Action	Action
Example	EXTREME HEAT ON SR-190 CARRY WATER	CHAIN CHECK POINT 1 MILE AHEAD INSTALL CHAINS NOW

Example of a 2 phase Message

	Message Elements	
	Phase 1	**Phase 2**
Line 1	Weather Descriptor	Audience for Action
Line 2	Location	
Line 3		Action
Example	SNOW ZONE ON US-50	VEH TOWING OR OVER 10,000 GVW CHAINS REQUIRED

Make Safety-Related Preparations: Example Features or Information for Open Format Text/Visual Messages

Website or other open-format features or content that provide information that supports traveler decision making are shown in the table below.

Useful Display Features	Information Elements
Route or Area Map 	• Location/extent of problem • Color coded major roads or areas affected
Text Information **Alert – Interstate 70 Eastbound** **Chains are required on Interstate 70 Eastbound between mile marker 205 and mile marker 213.** Last updated 2009-12-15 05:35:01 MST	• Location of affected area • Text description of preparations to take • Severity information e.g. extreme conditions, risk of stranding, emergency services not operating • Prominently displayed text box with attention-grabbing color, text, etc.

Make Safety-Related Preparations: Auditory Message Examples

The short text/visual message examples on the previous page provide prescriptive directions to drivers, while the auditory messages below provide informational advisories, along the lines of a public service announcement. Either strength of message is appropriate for either class of dissemination methods. Multiple example HAR or 511 auditory messages that are consistent with the auditory message guidelines provided in this report are shown below for this travel decision. The following messages are more suitable for HAR usage than 511 due to their length and references to the radio service.

Example: Carry Front and Rear Chains, make sure your Vehicle is in Good Operating Condition

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- At this time of year motorists traveling through (State) should always have front and rear chains. [Also, make sure your vehicle is in good operating condition before you start.]
- Highway patrols are on the highway.
- In the event of a breakdown, do not leave your vehicle. keep warm, use your hazard flasher lights, and park off the highway.
- [If available, use a CB radio]

- *Statements in brackets [ ] are optional
- Source: HAR Message Development Guide

Example: Chain Law

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- (State) has a chain law in effect during hazardous driving conditions
- If you do not have a fourwheel drive vehicle, you must have tire chains or snow tires.
- To put on tire chains either exit the Interstate or drive onto an emergency parking lane.
- Turn on your emergency flashers and never stand in a traffic lane while putting on or removing chains.

- *Statements in brackets [ ] are optional
- Source: HAR Message Development Guide

Example: If your Vehicle Breaks Down

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- If your vehicle should break down during a winter storm, do not panic.
- Stay in your vehicle.
- Run the engine, but be sure to leave a window open slightly to avoid carbon monoxide poisoning.
- Only run the engine for about 20 minutes each hour.
- Leave your flasher lights on and, leave the inside dome light on so work crews can see you.
- If your engine is stopped, keep your body warm by exercising in your vehicle.
- Keep active, but do not overexert in digging out of a snow drift.

- *Statements in brackets [ ] are optional
- Source: HAR Message Development Guide

Example: What to do if Caught in a Blizzard

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- This radio service was developed to aid motorists traveling on Interstate 90 between (City A) and (City B)
- [Stay tuned for advisories on roadway conditions which could affect your travel plans.]
- Alternate routes will be advised should Interstate 90 West be closed.

- Winter winds may result in blizzard conditions across (State's) high plains.
- If caught in a blizzard, drive slowly, stay calm, and watch out for other vehicles.
- It is advised to keep driving very slowly.
- If you must stop, be sure you are well off the roadway.
- If you cannot see the lane markings, look at the little posts along the side of the road. These posts will guide you in staying on the roadway.

- *Statements in brackets [ ] are optional
- Source: HAR Message Development Guide

TRAVEL DECISION 7: CANCEL TRIP

Introduction

This decision involves abandoning a trip, typically prior to leaving. It is also possible that travelers may cancel a trip en-route under more extreme circumstances, such as if conditions worsen significantly during their trip. The decision to cancel a trip can apply to a variety of scenarios. The most important is if travelers are unable to reach a destination, possibly because the routes are closed or the area is being evacuated. However, certain traveler groups may choose to cancel a trip even if conditions are less severe.

How can travelers use the information?

Available Traveler Actions	Travelers who Benefit from this Information	Key Information Needs	Dissemination Issues
Forced trip cancellation	All travelers	Destination is not reachable	Message must be communicated using all available dissemination methods
Voluntary trip cancellation	Older travelers, recreational travelers, and travelers with flexible schedules	Road weather conditions are challenging	None

Discussion

The decision to cancel typically has significant impacts on travelers' schedule (e.g., miss a return flight) and may include financial costs (e.g., cancellation fees, extra accommodation costs). Some travelers may be reluctant to cancel their travel plans because of these schedule and financial costs (see Tutorial 1 for more information on traveler adjustments). Consequently, the message communicating the need to cancel a trip should be unambiguous and convey the severity of the situation, including that travel to a destination is not permitted, not possible, or dangerous.

Some travelers will choose to cancel their travel under less severe conditions. More specifically, if travel to a destination becomes more challenging, some travelers may still cancel their trip, even though their destination is reachable, such as if intended routes are closed, driving requires a high degree of caution, or safety-related preparations are necessary. Trip cancellations of this type are more likely to be made by older drivers, recreational travelers, or those with more flexibility in their schedules. Information about the suitability of providing cancellation information at different trip stages is included in Tutorial 2.

Cancel Trip: Short Text/Visual Message Examples

For a short message, the key message elements are presented below, with each line corresponding to a DMS message line. For other short text message formats, the message elements are not required to be presented on separate lines; however if space is available, doing so may facilitate message comprehension.

	Message Elements	
	Baseline Message	**Message Without Recommended Action**
Line 1	Weather Descriptor	Weather Descriptor (Lanes Closed)
Line 2	Location	Location
Line 3	Recommended Action	Recommended Action
Example	HEAVY SNOW DONNER PASS NO UNNECESSARY TRAVEL	ALL LANES CLOSED DONNER PASS TUNE RADIO TO 1190 AM

Cancel Trip: Example Features or Information for Open Format Text/Visual Messages

Website or other open-format features or content that provide information that supports traveler decision making are shown in the table below.

Useful Display Features	Information Elements
Route Map	• Location/extent of problem • Color coded major roads or areas affected
Text Information	• Prominently displayed text box with attention-grabbing color, text, etc. • If very severe, such as a tornado, display text that takes over the page and users (travelers) must dismiss by clicking or other means • Location of affected area • Severity information i.e. reason for cancelling the trip
Camera	• Camera image allows drivers to get a better sense of the severity of the conditions and provides a good reason for drivers to trust the information

Cancel Trip: Auditory Message Example

This message may be more suitable for HAR than 511 due to its reference to local radio stations. However, the message could easily recommend that drivers listen to 511 instead.

Example: Forced trip cancellation

- Attention Westbound Interstate 90 traffic
- [This is (State) Highway Advisory Radio Station (Call Letters)]*
- Interstate 90 West is closed to thru traffic between (City A) and (City B)
- Snowfall and high winds have caused drifting snow and limited visibility
- Drivers headed westbound to (City C) are advised to remain in (City D)
- While in (City D) turn your radio to local stations 1190 or 1390 AM
- These stations will inform you of when Interstate 90 West to (City C) will be reopened
- [We regret this inconvenience]

*Statements in brackets [ ] are optional

Source: HAR Message Development Guide

TUTORIALS

TUTORIAL 1: TRAVELER ADJUSTMENTS BASED ON WEATHER INFORMATION

Summary: This tutorial provides additional information about the adjustments that travelers may make in response to weather information, in addition to the potential safety implications of these adjustments.

Types of adjustments that travelers make

There are many adjustments that travelers can make in response to weather information. Most of the information related to this topic is from studies involving traveler adjustments in response to traffic information, which is likely to be associated with a different set of travel adjustment factors overall. However, some elements, such as expected delays and route changes may be associated with comparable travel decisions related to weather events. In one study of traveler decision making, 40% of travelers were willing to change both departure time and route (35% of these respondents report changing trip based on weather information, vs. 89% for congestion, 86% for traffic reports, 44% for time pressure; Haselkorn & Barfield, 1990). Also, 21% were willing to change their route en-route, 16% were willing to make time, mode, or route changes prior to leaving home, while 23% were unwilling to change departure time. In another study, 60% of travelers reported changing their route or departure time based on radio traffic reports (Khattak, Schofer, & Koppelman, 1992). Finally, a study using travel diaries reported that 37% of trips for which traveler information was consulted resulted in some change in travel behavior (which represented 1% of total trips recorded; Peirce & Lappin, 2003). The most typical changes involved changes to departure time (13%) or route (11%), with only 1% of travelers changing mode.

The brief traveler questionnaire conducted in Task 4 of this project (Richard et al., 2009) provided some information specific to weather-related adjustments. The findings are somewhat different from those found in previous studies because the Task 4 responses were directly tied to a severe weather event that respondents encountered the past year, so they had a specific reason to consult weather information. Consequently, the overall percentage of travelers changing their plans is greater than in previous studies (see Figure E-1 below). Respondents reported changing their travel plans and behaviors in several different ways, with the most common responses being “Drove with more caution” (50%), “Left earlier” (42%), and “Took a different route” (36%). Note that multiple responses were possible, so some travelers may have made more than one of these adjustments during their travel. Overall, travelers seem quite willing to change their plans based on the weather information, a finding which is underscored by the fact that only 11% of respondents reported not changing their travel plans at all.

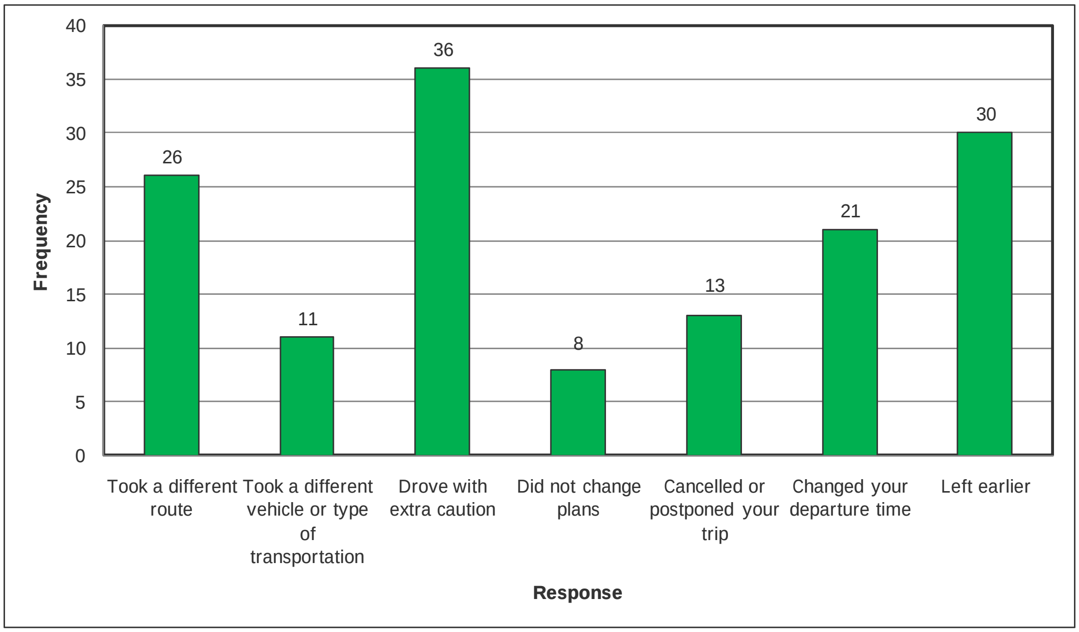


Figure E-1. Traveler adjustments based on weather information (from the questionnaire given earlier in this project).

Safety implications of the adjustments

It is not possible to examine the safety implications of the adjustments in a way that is tied directly into the types of adjustments that travelers make, since there was no related follow up information provided by the surveys covered. However, indirect information is given by the types of weather conditions that require information dissemination to preserve driver safety. In particular, there appear to be just a few general ways in which weather events and corresponding mobility impacts can affect safety. The first is that a traveler can end up at a location that jeopardizes personal safety, such as on a flooded road or where they are at risk of being stranded in harsh conditions (e.g., in a blizzard). The other safety implications relate to increased crash risk stemming from low visibility or low traction conditions.

We did not find data that addressed whether travel adjustments improve or reduce personal safety related to conditions such as being stranded, etc. However, the results of the Task 4 questionnaire from this project indicate that some travelers did make decisions that could have general personal safety benefits in certain situations (e.g., canceling their trip during heavy snow), but without more specific information it is difficult to quantify this benefit. Questionnaire results also provide a slightly better answer regarding driver behavioral adjustments to increased crash risk conditions. In particular, for the subset of 50 respondents who identified “slippery conditions” as a weather impact of concern in a previous question, 60% of these respondents indicated that they “drove with extra caution.” This finding clearly suggests that the travelers surveyed do use weather information to make safer travel decisions in certain crash-risk situations.

TUTORIAL 2: WHEN TRAVELERS USE WEATHER INFORMATION

Summary: This tutorial provides additional information about when travelers prefer to receive weather information relative to the start of their trip, and how suitable various Dissemination Methods are for providing information at different trip stages.

Several sources partially address the question of when travelers use weather information. In particular, one survey found that 15% of motorists sought weather condition information prior to departing (Emmerink, Nijkamp, Rietvald, & Van Ommeren, 1996). This study also found that motorists between the ages of 46-60, in addition to vacation and business travelers, were the most likely to seek out weather condition information prior to leaving. Another study reported the percentage of respondents rating information access as very or extremely important by trip stage, which included 52.3% of travelers having this opinion for before starting their trip, 47.8% for en-route, and 27.7% for stopped on-route (Patten, Pribyl, & Goulias, 2003). In contrast, another road weather survey found that travelers' preferred information access point depended on the type of traveler (Martin et al., 2000). More specifically, commuters and recreational travelers preferred getting information less than 1 hour before leaving and en-route; "travelers" preferred information at all intervals, with 1-2 days prior and en-route being the most common, and truckers preferred receiving information from up to 3 hours before departing to en-route.

The brief traveler questionnaire from Task 4 of this project also provided some timing information. Table E-3 below shows the percentage of respondents that reported that obtaining weather information at various points during their trip was either "Very Useful" or "Mostly Useful." In addition to this, the second row provides the same information for just the "Very Useful" response option. Prior to departing and on the road appear to be the most popular times to receive weather information, which is comparable to the findings from Martin et al. (2000).

Table E-3. Partial traveler responses to the most useful time to get weather information (from the questionnaire given earlier in this project).

	During Trip Planning	Prior to Leaving	At a Stopping Point	While Driving
Mostly Useful or Very Useful	63%	78%	57%	70%
Very Useful	37%	52%	30%	39%

One limitation of the survey findings is that they lack specific details about the specific travel decisions that travelers are making at various trip stages. This is useful information because trip stage limits the use of some dissemination methods (e.g., internet websites are not typically available while driving), which has implications for how various dissemination methods should be used to communicate certain types of information to travelers. In order to obtain a more detailed picture of how acceptable certain travel decision outcomes might be if they were made at specific stages during a trip, we evaluated each combination of travel decision and trip stage based on suitability of making a specific travel decision at that point (see Table E-4). We used a three-level classification scheme to characterize the "suitability" of a decision outcome based on the following categories:

- ***Suitable***: Travelers are still in a position to make a decision at this stage if they obtain relevant road weather information (even if it is not under optimal conditions: e.g., compensating for travel delays en-route may be more challenging than doing so during trip planning).
- ***Possibly too soon***: Weather information is obtained before a decision must be made, but it may come so early that there is a chance of forgetting the information by the time it is needed. For example, if drivers are warned about icy roads prior to leaving, they can still make use of this information; however, its effectiveness as a warning depends on how well drivers remember it, which can be unreliable.
- ***Too late***: The information is obtained once it is no longer possible to make this decision or if there is likely to be a high cost of doing so (e.g., canceling hotel reservations).

Table E-4. Qualitative ratings describing the likely suitability of making a specific travel decision at various trip stages.

	During Trip Planning	Prior to Leaving	At a Stopping Point	While Driving
Take alternative route?	Suitable	Suitable	Suitable	Suitable
Expect delays?	Suitable	Suitable	Suitable	Suitable
Drive with caution?	Possibly Too Soon	Possibly Too Soon	Suitable	Suitable
Delay departure?	Suitable	Suitable	Too Late	Too Late
Cancel Trip?	Suitable	Suitable or Too Late for Major Trips	Suitable or Too Late for Major Trips	Too Late
Change Mode?	Suitable or Possibly Too Soon	Suitable	Too Late	Too Late
Make special preparations?	Suitable or Possibly Too Soon	Suitable	Too Late	Too Late

More specific information regarding the timing of traveler information needs relative to the onset of the weather event could not be found. However, one traveler survey did ask about the timing of information needs relative to the start of the trip (Martin et al., 2000). The results of this survey (shown in Figure E-2 below) suggest that the importance of receiving weather information over time relative to the trip start varied as a function of traveler type. In particular, most drivers viewed receiving information less than 1 hour prior to leaving and while en-route as being the most important, but truckers rated 1-3 hours before as the most important and the "traveler" group rated 1-2 days before as among the most important times. These differences are likely to be related to the types of travel adjustments that different types of travelers need to make. One caveat of these findings is that technology use patterns and availability of travel information on various dissemination methods have changed significantly since then (Martin et al., 2000).

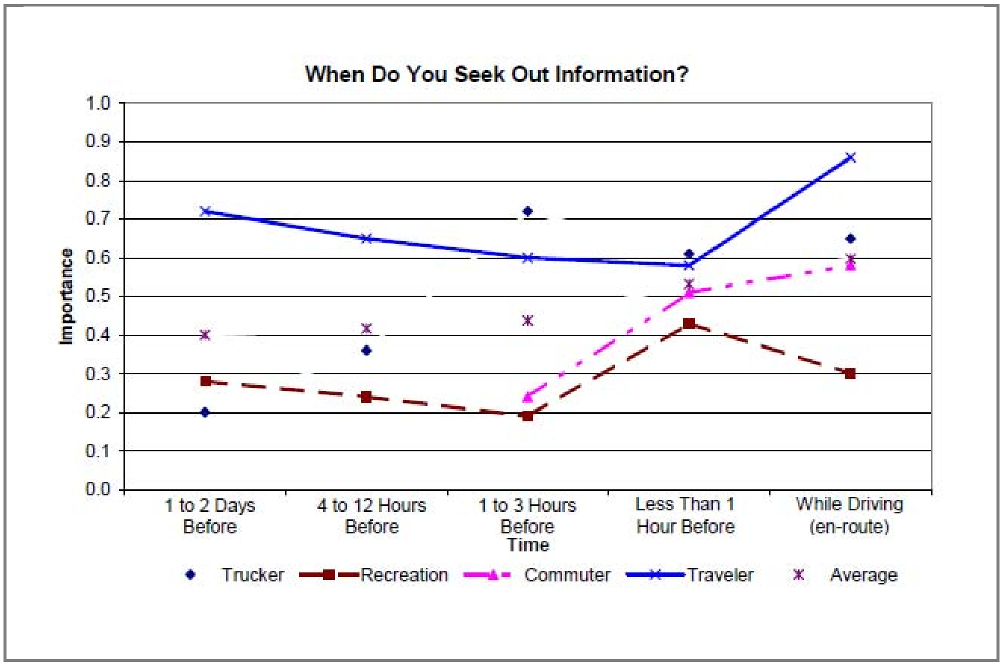


Figure E-2. Graph showing the rated importance of receiving weather information at different times relative to the start of a trip (from Martin et al., 2000).

This study also asked about the timing of the information relative to the location of the event. In general, the highest responses were obtained for locations within 50 miles of a weather event or within a specific travel corridor (see Figure E-3).

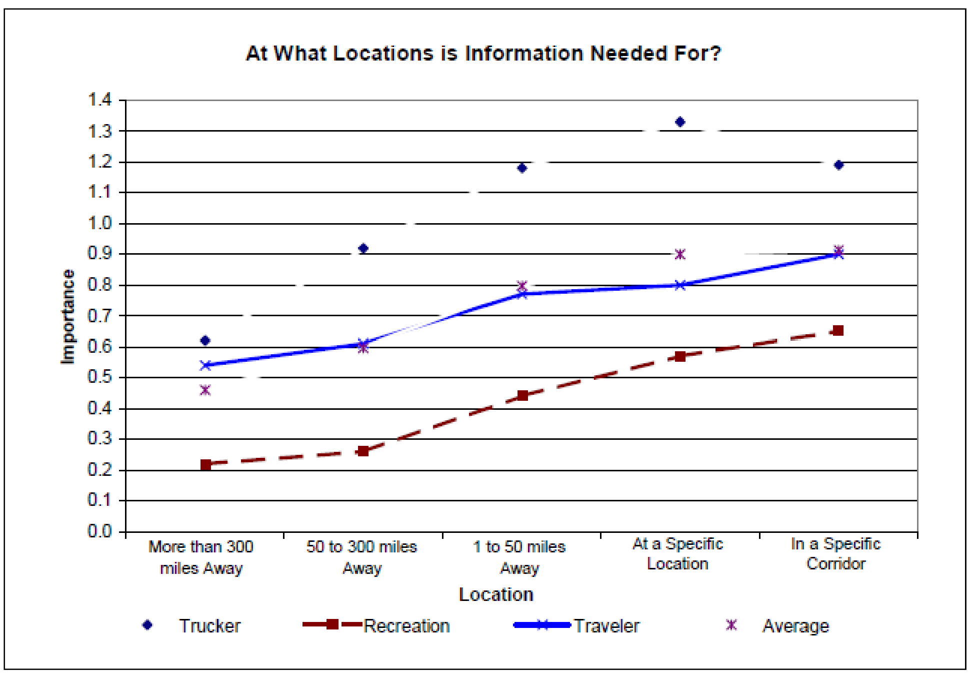


Figure E-3. Graph showing the rated importance of receiving weather information at different distances relative to the location of a weather event (from Martin et al., 2000).

TUTORIAL 3: HOW TO DETERMINE WHICH DISSEMINATION METHODS TRAVELERS WILL USE

Summary: This tutorial provides additional information about the availability of various Dissemination Methods at different trips stages, in addition to information about traveler awareness of and preferences for specific Dissemination Methods.

Availability of Dissemination Methods

There does not seem to be any specific data about dissemination method availability or traveler access to disseminations methods during their travel. However, it was possible to analytically determine when most dissemination methods would likely be available to travelers based on how each technology functions. We categorized the dissemination methods in one of four ways based on its likely availability during four basic trip stages. The categories included:

Available: There are no obvious barriers to using this dissemination method

Available at Certain Locations: The dissemination method could be available at this stage, but this is unlikely to be true everywhere (e.g., some common stop-over such as restaurants may have TV or wireless internet access, but others such as rest areas likely do not)

Not Available: It is impossible or impractical to access this dissemination method at this trip stage

Potential distraction: The dissemination method can be accessed during this stage, however, doing so could potentially pose a safety-related distraction-risk to drivers. Information from Task 4 activities was used to identify distraction risks.

A summary of when most dissemination methods would likely be available to travelers is provided below in Table E-5.

Table E-5. Dissemination method availability for different trip stages.

Dissemination Method	During Trip Planning	Prior to Leaving	At a Stopping Point	While Driving
Road Weather Information Kiosks	Not Available	Not Available	Available at Certain Locations	Not Available
511	Available	Available	Available	Potential Distraction
GPS/ Personal Electronic Devices	Available	Available	Available	Potential Distraction
Cell phone/Text Messaging	Available	Available	Available	Potential Distraction
Weather Information Website	Available	Available	Available at Certain Locations	Not Available
Commercial Radio Weather Forecasts	Available	Available	Available	Available
TV Weather Forecasts	Available	Available	Available at Certain Locations	Not Available
HAR	Not Available	Not Available	Available at Certain Locations	Available
DMS	Not Available	Not Available	Not Available	Available

Traveler Awareness of Different Dissemination Methods

Another factor affecting the dissemination methods that travelers use is their awareness of the different methods. If the travelers are unaware of a method, they will not have the option of using it. In the questionnaire from this project, travelers were asked which dissemination methods they were aware of. The results are included in Figure E-4 below.

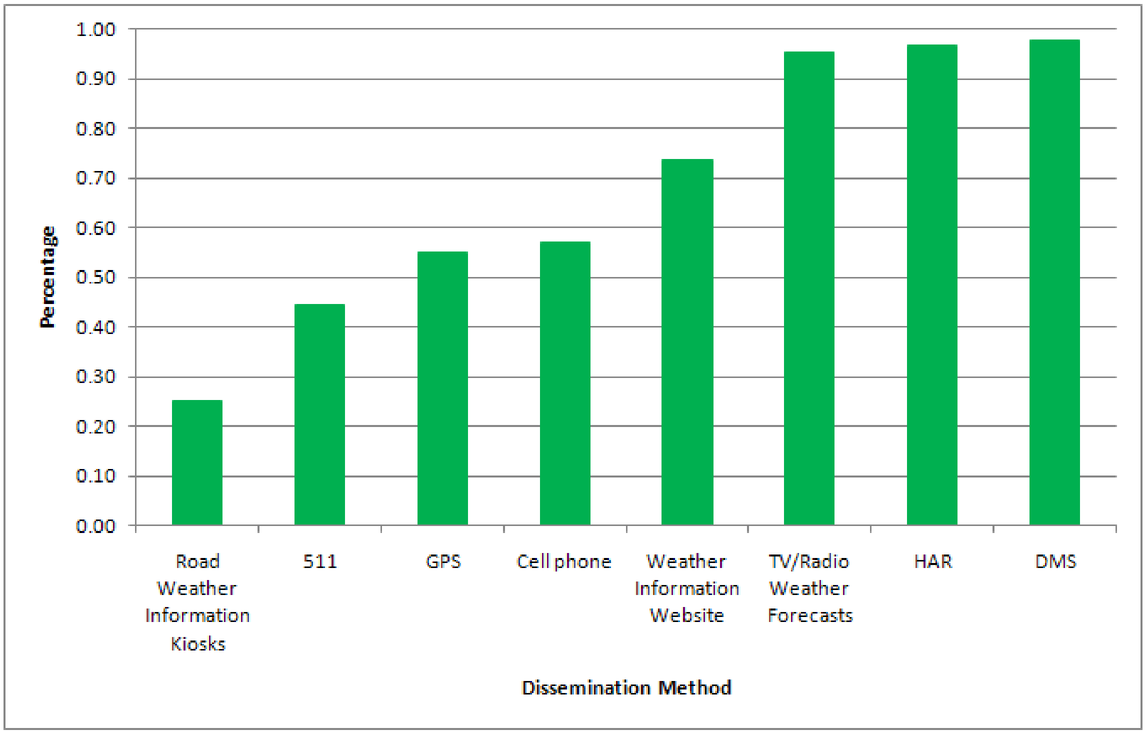


Figure E-4. Percent of travelers aware of each dissemination method.

It should be noted that this questionnaire was conducted in Northwestern Washington State and that traveler awareness could be partially a function of the availability of the dissemination methods in that area. However, some strong trends are likely to apply across geographic groups. TV/Radio weather forecasts, HAR, and DMS are all well known methods, whereas kiosks are much less commonly known.

Traveler Preferences for Different Dissemination Methods

Overall, the limited existing research information makes it difficult to understand traveler preferences with a high degree of confidence. A few reports provided some specific findings related to dissemination preferences of select groups, such as business travelers were more likely to change their routes than commuters based on DMS traffic information (Emmerink, et al., 1996; see also Peirce & Lappin, 2003).

One research study examined this issue comprehensively; however, the results are from 2000, and technology use patterns and availability of travel information on various dissemination methods have changed significantly since then (Martin et al., 2000). Results from Martin et al. are shown in Figure E-5 below. Nevertheless, the general pattern, especially for more established dissemination methods, such as DMS/CMS (Changeable Message Sign), HAR, commercial radio/TV and perhaps kiosks, may still hold. With the exception of travelers’ preference for kiosks and truckers’ limited use of TV, preference patterns are similar across traveler types. The other dissemination methods in which differences are observed, such as phone and web, likely have different usage patterns since the survey was conducted.

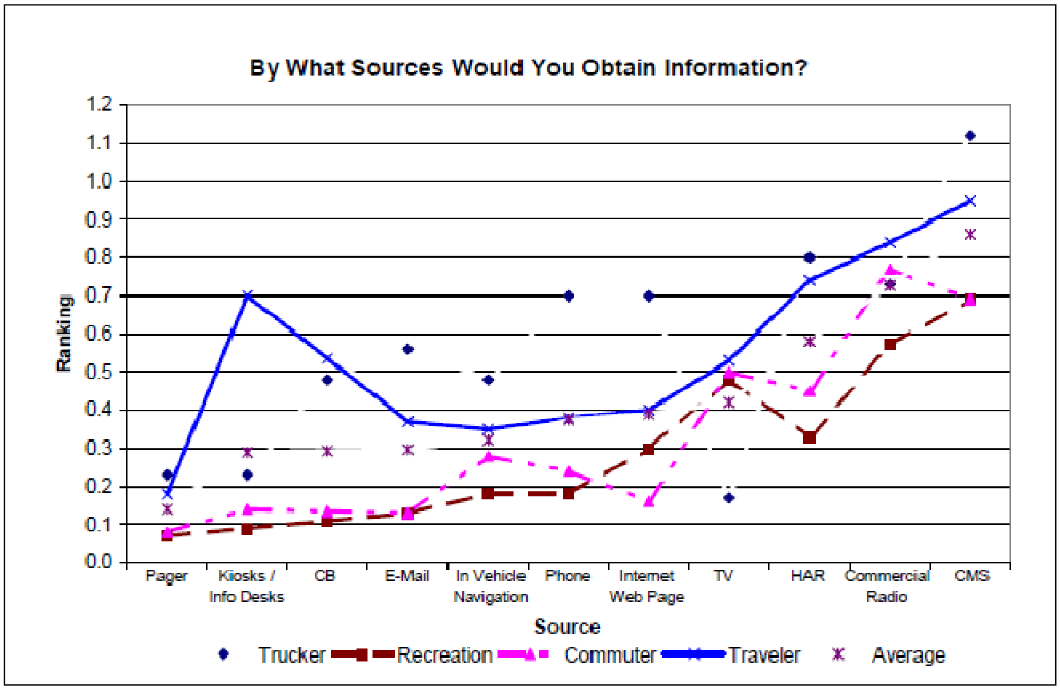


Figure E-5. Dissemination method preference by traveler type (from Martin et al., 2000).

TUTORIAL 4: SAFETY IMPLICATIONS OF ROAD WEATHER INFORMATION

Summary: This tutorial provides additional information about how safety/mobility impacts for certain weather events can affect drivers' personal safety, crash risk, and convenience or schedules. Safety/mobility impacts are generally characterized along these dimensions, which can be useful for prioritizing the importance of specific messages.

An important use for road weather information is to preserve traveler safety. Crash data analyses provide a partial indication of which conditions require information. For example, it is clear that certain weather impacts, such as low traction and low visibility play a major role in crashes and fatalities (e.g., Maze, Agarwal, & Burchett, 2005; Pisano, Goodwin, & Rossetti, 2008). Other evidence also suggests that speed reductions are associated with increased crash risk arising from greater speed variability on a roadway (e.g., Hauer, 1971); however, there is some controversy regarding the interpretation of these results (e.g., Davis, 2002). We did not find data showing how weather-related lane obstructions and "reduced traffic capacity" were directly related to crash risk. However, it is not unreasonable to expect that these impacts may increase crash risk in some way, although the relationship may also be less direct (e.g., other related factors such as low traction contribute) or these types of events less common in general.

Crash data do not provide a complete description of the safety impacts and other major ways in which road weather information can help travelers avoid personal safety risks and other undesirable conditions, such as significant unexpected schedule disruptions. In order to obtain a more complete picture of traveler impacts, we used a systematic approach to characterize the general level of risk potentially associated with each mobility impact with regard to personal safety, crash risk, and schedule/convenience impacts. This information can be useful for prioritizing weather impacts. Also, by adding in information about schedule/convenience impacts, it makes it possible to provide an additional basis for prioritizing certain impacts that do not have associated safety consequences. Note that no attempt was made to align the risks from each dimension along the same "severity" scale; however, the personal safety and crash risk consequences are clearly more severe than any of the convenience impacts.

The results of this analysis are presented in Table E-6 below. Two severity levels were used for each dimension, a major or direct risk (solid circle) or a minor/potential risk (empty circle), the latter case representing impacts that are less severe or less likely to occur. Note that for some weather impacts, the associated type of risk was inherent in the definition of the mobility impact (e.g., disruption to transit schedules by definition involves major schedule impacts to travelers dependent on transit). The severity categories were defined as follows:

- **Personal Safety Risks**
    - *Direct Risk to Personal Safety (●)*: Safety/mobility impacts could endanger travelers if they are not prepared or disregard warnings (e.g., becoming stranded on the road during a snow storm).
    - *Potential Risk to Personal Safety (○)*: Safety/mobility impacts could endanger travelers if they are not prepared or disregard warnings, but the connection is more dependent on situational factors which may be uncommon (i.e., if a road is closed because of a hazard, such as avalanches or rock slides).

  - *No impact indicated (–)*: The safety/mobility impact likely has no obvious impact on personal safety.
- **Crash Risks**
  - *Direct Crash Risk (●)*: Crash data suggest a likely causal relationship between these factors.
  - *Potential Crash Risk (○)*: Crash data are less clear regarding a causal relationship, or this type of crash risk is relatively uncommon.
  - *No impact indicated (–)*: The safety/mobility impact likely has no obvious impact on crash risk.
- **Convenience/Schedule Impacts**
  - *Major Convenience / schedule impacts (●)*: Indicates that one of the primary impacts will not necessarily be a safety risk, but travelers may suffer some other consequences in terms of meeting their schedules or being inconvenienced in some way, that might otherwise have been avoidable had they received appropriate information.
  - *Minor Convenience / schedule impacts (○)*: Traveler schedules or convenience could be affected, but other factors (e.g., low traffic volumes from other travelers staying away) may mitigate these impacts.
  - *No impact indicated (–)*: The mobility impact would not be expected to cause unreasonable impacts on traveler schedule and convenience.

Table E-6. Potential traveler risks for the basic set of mobility impacts. Information about corresponding weather events and specific impacts on travelers is included in the table to provide additional context when evaluating risks.

Safety/Mobility Impact	Associated Conditions	Impact on Travelers	Personal Safety Risk	Crash Risk	Convenience / Schedule Impacts
Total Road Closure	Blizzard conditions, White-out conditions, Moderate to heavy snow, Sleet or freezing rain, Flooding, Thunderstorms, High winds	Requires detour onto alternate routes or delaying travel.	○	–	●
Reduced traction	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain	Drivers should be more cautious in the affected area.	–	●	○
Low visibility	Blizzard conditions, White-out conditions, Blowing snow, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Smoke/mist/fog	Drivers should be more cautious in the affected area.	–	●	○
Lane Obstruction/ Reduced capacity	Blizzard conditions, White-out conditions, Blowing snow, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Drizzle or light rain, Flooding, Thunderstorms, High winds, Smoke/mist/fog	Likely to cause moderate to high levels of traffic congestion in the immediate area. Debris on roadway, lanes unavailable because of snow obstruction/ clearing or partial flooding. Also, vehicles pulling over to side of road, washed out roadways or pavement damage.	–	○	●
Congestion/ Reduced speed	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Flooding, Smoke/mist/fog	Greater speed variability in traffic and loss of roadway capacity.	–	○	○
TCD Malfunction	Blizzard conditions, White-out conditions, Moderate to heavy snow, Sleet or freezing rain, Thunderstorms, High winds	Traffic signals are non-operational leading to increased congestion.	–	–	●
Unsteady Driving/ High Winds	High Winds	Drivers (particularly those of larger vehicles/trucks, RVs) should be more cautious in the affected areas.	–	●	–

Safety/Mobility Impact	Associated Conditions	Impact on Travelers	Personal Safety Risk	Crash Risk	Convenience / Schedule Impacts
Flooding/ Water Ponding	Moderate to heavy rain, Flooding, Thunderstorms	Drivers are at risk of being stuck or stranded mid-travel. Potential road closures. Drivers should be more cautious in the immediate area.	●	○	●
Maintenance Vehicles on Road	Blizzard conditions, Blowing snow, Bridge or road frost, Extreme cold, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Flooding, Extreme heat	Drivers should be more cautious in the affected area. Maintenance vehicles on the road may reduce roadway capacity, leading to increased congestion.	–	○	○
Transit, Bus Delays/ Stoppage	Blizzard conditions, White-out conditions, Blowing snow, Bridge or road frost, Extreme cold, Flurries or light snow, Moderate to heavy snow, Sleet or freezing rain, Moderate to heavy rain, Flooding, Thunderstorms, High winds, Smoke/mist/fog	Travel by transit has a higher time cost.	–	–	●
Sun Glare	Extreme heat, Fair weather	Drivers should be more cautious in the affected area.	–	○	–
Extreme Temperatures	Extreme cold, Extreme heat	Drivers should prepare for conditions by bringing along appropriate gear/supplies.	●	–	–

APPENDIX F.
WEATHER WEBSITE SURVEY RESULTS

Table F-1. Links and other dissemination methods.

State/Provider	Homepage link(s)	Weather-related links on the DOT Homepage	Support other dissemination methods	Links
Alabama	http://www.dot.state.al.us/docs	Emergency road closures, traffic cameras	Y - Link for using a mobile device	Link to NOAA from traffic camera page
Alaska/ Alaska 511	http://511.alaska.gov/ http://www.dot.state.ak.us/	Highways → road weather information system; 511	N	511 incorporated
Arizona	http://www.dot.state.az.us/	Road conditions, traffic cameras	Y - Mobile homepage for travel times	511 - included here since incorporated with site
Arkansas	http://www.arkansashighways.com/	Weather condition map	N	N
California	http://www.dot.ca.gov/	Travel → Highway conditions, live traffic cameras	Y - mobile	Link to 511
Colorado	http://www.dot.state.co.us/	Road/Weather conditions/web cameras, travel advisory alerts and restrictions	Y - mobile	N
Connecticut	http://www.ct.gov/dot/site/default.asp	Weather	N	N
Delaware	http://www.deldot.gov/	Interactive traffic map, live traffic, traffic alerts	N	N
District of Columbia (Washington DC)	http://www.ddot.dc.gov/ddot/site/	Traveler information, traffic cameras	N	N
Florida/ Florida 511	http://www.dot.state.fl.us/ http://www.fl511.com/Default.aspx	Travel information, traffic warnings and updates, 511	N	511 incorporated, National Weather Service (hurricanes), Florida Division of Forestry (wildfires), Florida FHP
Georgia	http://www.dot.state.ga.us/Pages/default.aspx	Travel Info	Y - My NaviGAtor has subscriptions for PED/email	Some information on Georgia Navigator site www.georgia-navigator.com
Hawaii	http://hawaii.gov/dot/	None	N	N
Idaho	http://itd.idaho.gov/	Traveler services → 511 Idaho, cameras, weather	N	Adjacent states/ Canadian provinces

State/Provider	Homepage link(s)	Weather-related links on the DOT Homepage	Support other dissemination methods	Links
Illinois	http://www.dot.state.il.us/	Traveling public → Winter road conditions, road conditions; Road closures → current closures; Maps → Interactive maps	N	Map on www.gettingaroundillinois.com
Indiana	http://www.in.gov/indot/	Road conditions, traffic-wise	N	Links to Intellicast, National Weather Service, Wunderground
Iowa/ Iowa 511	http://www.iowadot.gov/ http://www.511ia.org	Weather, forecast	N	511 incorporated
Kansas	http://www.ksdot.org/	Travel and Traffic Info → Road Weather Station, Maps	Y - 511 mobile	511, weatherforyou.com incorporated
Kentucky 511	http://511.ky.gov/	None	N	All 511 info
Louisiana	http://www.dotd.state.la.us/	Louisiana traffic times (511), traffic cameras	N	511 incorporated
Maine 511	http://www.511maine.gov/index.asp	None	N	All 511 info
Maryland	http://www.mdot.state.md.us/	Miscellaneous → Local Weather	N	N - all info on CHART page which is part of the DOT
Massachusetts	http://www.massdot.state.ma.us/Highway/	Traveler Information (w/ 511 logo)	N	N
Michigan	http://www.michigan.gov/mdot/	Lane closures, winter road conditions	N	N
Minnesota/Minnesota 511	http://www.dot.state.mn.us/ http://www.511mn.org/index.asp	Twin Cities Metro Traffic, Getting Around, weather	Y - 511 mobile	511 incorporated
Mississippi	http://www.gomdot.com/Home/Home.aspx	Monitor traffic conditions, Travel → Weather	N	N
Missouri	http://www.modot.mo.gov/	Traveler information map, statewide text report of road closures, road conditions update	N	N
Montana	http://www.mdt.mt.gov/	Traveler information → alerts/restrictions/road reports, cameras/RWIS, weather	N	511 - included here since incorporated with site
Nebraska/Nebraska 511	http://www.dor.state.ne.us/ http://www.511nebraska.org/ndortip/index.jsp	Winter storm related bulletin, highway cams, city cams, weather	N	511 incorporated
Nevada 511	http://www.safetravelusa.com/nv/	Highway controls report, links to various maps	N	All 511 info

State/Provider	Homepage link(s)	Weather-related links on the DOT Homepage	Support other dissemination methods	Links
New Hampshire	http://www.nh.gov/dot/index.htm	Traveler/Commuter info	Y - link on 511 page for mobile devices	511 - included here since incorporated with site
New Jersey	http://www.state.nj.us/transportation/	Njcommuter.com → NJ511 Travel Info, Cameras	Y - Email or text alert feature	511 - included here since incorporated with site
New Mexico	http://www.nmshtd.state.nm.us/	Roads and Traffic, Road Conditions 511	N	Links to surrounding states road conditions
New York 511	http://www.511ny.org/	Traffic conditions, transit conditions	N	All 511 info
North Carolina	http://www.ncdot.org/	Travel and Maps	N	None
North Dakota	http://www.dot.nd.gov/	Road Conditions Info	N	None
Ohio	http://www.dot.state.oh.us/Pages/Home.aspx	Highways	N	Most info on www.buckeyetraffic.org, link to FHWA National Traffic and Road Closures site
Oklahoma	http://www.okladot.state.ok.us/	Public Access Traffic Webcams, Road Conditions, Weather Information	Y	NOAA
Oregon	http://www.oregon.gov/ODOT/	Trip Check (external)	Y - PED	All info on www.tripcheck.com
Pennsylvania 511	http://www.511pa.com	Pennsylvania 511	N	All 511 info
Rhode Island	http://www.dot.state.ri.us/	Traffic → travel advisories, highway cameras, traffic management center, incident reports, 511 Travel information, Congestion mapping	N	511 - included here since incorporated with site
South Carolina	http://www.dot.state.sc.us/	Traffic cameras, SC Road conditions	N	None
South Dakota	http://www.sddot.com/	Link to safe travel USA - Road/weather Info	N	All info on safetravelusa.com
Tennessee	http://www.tdot.state.tn.us/	TDOT Smartway	N	None
Texas	http://www.dot.state.tx.us/	Road Conditions	N	None
Utah	http://www.udot.utah.gov/	Road Conditions	N	511 - included here since incorporated with site, map on commuterlink.utah.gov
Vermont 511	http://www.511vt.com	511	N	All 511 info
Virginia 511	http://511virginia.org	511	Y - mobile	All 511 info
Washington State	http://www.wsdot.wa.gov/	Traffic and Cameras	N	None

State/Provider	Homepage link(s)	Weather-related links on the DOT Homepage	Support other dissemination methods	Links
West Virginia	http://www.transportation.wv.gov/Pages/ default.aspx	Road conditions	N	None
Wisconsin 511	http://www.511wi.gov	511	N	All on 511 except RWIS info
Wyoming	http://www.dot.state.wy.us/wydot/	511 travel info (not 511 page), road conditions, road condition alerts	N	None
Accuweather	www.accuweather.com	-	Y - mobile	-
BBC Weather	www.news.bbc.co.uk/weather/	-	Y - mobile	-
Intellicast	www.intellicast.com	-	Y - email	-
Met Office	www.metoffice.gov.uk	-	Y - email	-
National Weather Service	www.nws.noaa.gov	-	Y - mobile	-
Weather Underground	www.wunderground.com	-	Y - mobile	-
Weather.com	www.weather.com	-	Y - weather alerts by email, mobile text, or mobile vocal	-
Weatherbug	www.weatherbug.com	-	Y - mobile	-

Table F-2. Weather maps.

State/Provider	Weather-related map	Platform	Map detail	Weather-related color codes/symbols	Special areas indicated	Initial level of detail	Time-stamp
Alabama	N	-	-	-	-	-	-
Alaska/ Alaska 511	Y	Unknown	State to street	Y - Alerts, color coding for driving conditions, mountain pass symbols	Y	State	N
Arizona	Y	Unknown	State to region	Y - symbols but no color coding	N	State - select a region	Y
Arkansas	Y	Corel	State	Y - color coded roadways	N	State	Y
California	Y	Unknown	State to district, only closures	N	N	State	N
Colorado	Y	Google	State to street	Y - closures, cameras, colored roads	N	State	Y
Connecticut	Y	Google	State to street	N	N	State	N
Delaware	Y	Google	State to street	Y - Suns where the sensors are located	N	State	Y
District of Columbia (Washington DC)	N	-	-	-	-	-	-
Florida/ Florida 511	Y	Google	State to street	Y - Weather, traffic speed road color codings	N	State - select a region	Y
Georgia	N	-	-	-	-	-	-
Hawaii	N	-	-	-	-	-	-
Idaho	Y	Unknown	State to region	Y - Color coded roadways for driving conditions, links to NWS forecasts, watches, and warnings	Y	State	N
Illinois	Y	NAVTEQ	State to street	Y - Color coded roadways for snow/ice cover	N	State	Y
Indiana	Y	Traffic Wise page - Google	State to street	Y - Weather, coded road conditions, closures	N	State	N

State/Provider	Weather-related map	Platform	Map detail	Weather-related color codes/symbols	Special areas indicated	Initial level of detail	Time-stamp
Iowa/ Iowa 511	Y	Unknown	State to region	Y -color coded roads for precipitation coverage, symbols for driving condition difficulty	N	State	N
Kansas	Y	Bing	State to region	Y - color coded roads for precipitation coverage	N	State	N
Kentucky 511	Y	Google	State to street	Y - road conditions symbol, precipitation and hazardous driving conditions color colored	N	State	N
Louisiana	Y	Google	State to street	Y - weather icon, no color coding	N	State	Y
Maine 511	Y	Unknown	State to region	Y - color coded areas for driving conditions	N	State	N
Maryland	Y	Google	State to street	Y -alphabetical characters for road conditions, color coded roads by speed	N	Region	N
Massachusetts	Y - traffic only	Google	State to street	Y - Color coding for traffic levels, no weather info	N	Region	N
Michigan	Y - traffic only	Unknown	State to street	Y -Color coding for traffic levels, no weather info	N	State	N
Minnesota/ Minnesota 511	Y	Unknown	State to region	Y -color coding for driving conditions, alerts, accidents, closures	N	State	N - stated curre nt
Mississippi	Y	accuweather.com	State	Y - Color coding for precipitation levels	N	State	Y
Missouri	Y	Google	State to street	Y - Winter road conditions color coding, symbols for flood and winter weather	N	State	N
Montana	Y	Unknown	District	Y - color coded roadways by condition	N	State - select a region	Y
Nebraska/ Nebraska 511	Y	Unknown	State to city	Y - colored roads for caution level, symbols for road conditions info	N	State	Y

State/Provider	Weather-related map	Platform	Map detail	Weather-related color codes/symbols	Special areas indicated	Initial level of detail	Time-stamp
Nevada 511	Y	Unknown	State to route	Y -colored roads for chains, winds, closures	N	State	N
New Hampshire	Y	Google	State to city	Y - colored roads for road conditions, weather icon	N	State	N
New Jersey	Y	Google	State to street	Y - color coded traffic levels and weather icon	N	State - select a region	N - Stated current
New Mexico	Y	Unknown	State	Y -driving condition, closure, and weather advisories, no color codes	N	State	N
New York 511	Y	Google	State to street	Y -Weather alerts, color coded roads for speeds	N	State	N
North Carolina	Y	Bing	State to street	Y - color coding for traffic speeds	N	State	Y
North Dakota	Y	Unknown	State	Y - color coding for road conditions, flooding symbol	N	State	Y
Ohio	Y	Bing	State to street	Y - color coding for traffic speeds; flooding, snow/ice, road and weather sensor symbols	N	State	N
Oklahoma	Y	Unknown	State	Y - Color coded regions for weather conditions	N	State	Y
Oregon	Y	Unknown	State to route	Y - Symbols for weather hazard, weather warning, snow zone, weather stations, delays	N	State	N
Pennsylvania 511	Y	Google	State to street	Y - winter road conditions, weather alerts, roads color coded for winter weather or speeds	N	State	N
Rhode Island	Y	Unknown	State to region	Y - colored driving condition symbols, NWS weather watch and warning symbols, color coded roads for traffic flow	N	State	N
South Carolina	N	-	-	-	-	-	-

State/Provider	Weather-related map	Platform	Map detail	Weather-related color codes/symbols	Special areas indicated	Initial level of detail	Time-stamp
South Dakota	Y	Safe Travel	State	Y - road coding by weather conditions, traffic congestion symbols	N	State	N
Tennessee	Y	Google	State to street	Y - roads color coded by traffic flow, areas color coded by condition	N	State - select a region	N
Texas	Y	Unknown	State to route	Y - color coded roads for flood, ice/snow	N	State	Y
Utah	Y	Google	State to route	Y - color coded roads for traffic flow levels, sun and clouds for areas with weather info, blinking if severe	N	Region	N
Vermont 511	Y	Google	State to street	Y - color coded roads for road conditions, weather symbol	N	State	N
Virginia 511	Y	Bing	State to street	Y - colored roads for snow/ice conditions, cloud icons for weather conditions that have affected roads (e.g. flooding)	N	State	N
Washington State	Y	Unknown	State to region	Y - colored impact levels for alerts, weather symbol for impact type, color coded roads - traffic levels	Y	State - select a region	N
West Virginia	Y	ESRI	State to street	Y - color coded roads for clear, snow/ice removal, emergency	N	State	N
Wisconsin 511	Y	Google	State to street	Y - color coded roads for winter road conditions	N	State	Y
Wyoming	Y	Google	State to street	Y - color coded roads for surface conditions and atmospheric conditions	N	State	N
Accuweather	Y	Unknown	Country to region	Y - areas color coded by weather impact	N	Varies	Y
BBC Weather	Y	Unknown	Country	Y - areas color coded by weather impact	N	Country	Y
Intellicast	Y	Unknown	Country to region	Y - areas color coded by weather impact	N	State	Y

State/Provider	Weather-related map	Platform	Map detail	Weather-related color codes/symbols	Special areas indicated	Initial level of detail	Time-stamp
Met Office	Y	Unknown	Country to region	Y - icons for specific weather impacts	Y	Country	Y
National Weather Service	Y	Unknown	Country to region	Y - areas color coded by weather impact or road conditions	N	Region	Y
Weather Underground	Y	Unknown	State to region	Y - areas color coded by weather impact	N	Partial state	Y
Weather.com	Y	Bing	Region	Y - areas color coded by weather, roads by traffic level	N	Region	Y
Weatherbug	Y	Unknown	Country to state	Y - areas color coded by weather impact	N	State	Y

Table F-3. Live cameras or static images.

State/Provider	Live cameras/static images	Platform	Time-stamp	Update frequency	Precise location information including direction of travel
Alabama	Y - live	Windows Media Player	N - live	N - Pans/ tilts/ zooms at unknown intervals	Y
Alaska/Alaska 511	Y - static images	Unknown	Y	N - looped static images every 5-15 minutes	Y
Arizona	Y - static images	Images provided by 511	Y	N	Y
Arkansas	N	-	-	-	-
California	Y - live	Unknown	N - live	N - assumed live	Y - cross roads but not directional
Colorado	Y - static images	Unknown	Y	N	Y
Connecticut	Y - static images	TrafficLand	N	N - every 2-3 s	Y
Delaware	Y - live	Unknown	Y	Y - live	Y - cross roads but not directional
District of Columbia (Washington DC)	Y - live	TrafficLand	N - live	Y - live	Y - cross roads but not directional
Florida/Florida 511	Y - static images	Unknown	Y	N	Y
Georgia	Y - static images	Unknown	Y	N	Y
Hawaii	N	-	-	-	-
Idaho	Y - static images	Unknown	Y	N	Y - cross roads but not directional
Illinois	N	-	-	-	-
Indiana	Y - static images	Unknown	Y	N - rotating cameras	Y
Iowa/Iowa 511	N	-	-	-	-
Kansas	N	-	-	-	-
Kentucky 511	Y - static images	Unknown	Y	N	Y
Louisiana	Y - live	TrafficLand	Y	Y - live	Y
Maine 511	Y - static images	Unknown	Y	N	Y - cross roads but not directional
Maryland	Y - live	Unknown	Y	Y - live	Y - cross roads but not directional
Massachusetts	Y - static images	Unknown	N	N - almost live, every 5-10 s	Y - show comparative shots to figure out direction
Michigan	Y - live	TrafficLand	Y	Y - live, updated every 2 s	Y - cross roads but not directional
Minnesota/Minnesota 511	Y - static images	Unknown	Y	N - about every 20 s	Y - show comparative shots to figure out direction
Mississippi	Y - static images	Windows Media Player	N	Y - every 5 (-10) s	Y - cross roads but not directional
Missouri	N	-	-	-	-
Montana	Y - static images	SCAN Web	Y	N - looped static images every 1 hour	Y - cross roads but not directional
Nebraska/Nebraska 511	Y - static images	Unknown	Y	N	Y

State/Provider	Live cameras/static images	Platform	Time-stamp	Update frequency	Precise location information including direction of travel
Nevada 511	N	-	-	-	-
New Hampshire	N	-	-	-	-
New Jersey	Y - static images	Unknown	Y	Y - every 30-60 s	Y
New Mexico	N	-	-	-	-
New York 511	Y - static images	Unknown	N	N - about every minute	Y
North Carolina	Y - static images	Unknown	Y	N	N
North Dakota	Y - static images	Some by SCAN Web, others private	Y	Varies	Y
Ohio	Y - live	Unknown	Y	N - every 4-5 s	Y
Oklahoma	Y - static images	Unknown	Y	N	Y
Oregon	Y - static images	Tripcheck.com	Y	N	Y
Pennsylvania 511	Y - live	Unknown	Y	N - almost live, every 2-3 s	Y
Rhode Island	Y - static images	Unknown	Y	N - about every 20 s	Y - show comparative shots to figure out direction
South Carolina	Y - static images	Unknown	Y	N	Y
South Dakota	Y - static images	Unknown	Y	N	Y
Tennessee	Y - live	TrafficLand	Y - live	Y - live	Y
Texas	Y - live	Pegasis	Y	N - almost live, every 2-4 s	Y - cross roads but not directional
Utah	Y - static images	Unknown	Y	N	Y - cross roads but not directional
Vermont 511	Y - static images	Unknown	Y	N	N
Virginia 511	Y - live	Unknown	Y - live	Y - live	Y
Washington State	Y - static images	Unknown	Y	N	Y - cross roads but not directional
West Virginia	N	-	-	-	-
Wisconsin 511	Y - static images	Unknown	Y	N	Y - cross roads but not directional
Wyoming	Y - static images	Unknown	Y	N	Y
Accuweather	N	-	-	-	-
BBC Weather	N	-	-	-	-
Intellicast	N	-	-	-	-
Met Office	N	-	-	-	-
National Weather Service	N	-	-	-	-
Weather Underground	Y - static images	Unknown	Y	N	Y - weather camera images, not for road weather
Weather.com	N	-	-	-	-
Weatherbug	Y - static images	Unknown	N	Y - every 3 seconds	Y

Table F-4. Daily weather updates.

State/Provider	Daily weather update	Daily weather update format	Daily update page	Daily update media
Alabama	N	-	-	-
Alaska/Alaska 511	Y	Link to NWS forecast	511 homepage	Maps
Arizona	N	-	-	-
Arkansas	N	-	-	-
California	N	-	-	-
Colorado	Y	Current forecast info with map	Map page	N
Connecticut	Y	Weather forecast by city	Main page	N
Delaware	Y	Forecasts embedded by NOAA	Weather	Radar map by Intellicast
District of Columbia (Washington DC)	N	-	-	-
Florida/Florida 511	Y	Forecasts embedded by the Weather Channel, radar by radar.weather.gov	Emergency Management Home	Radar map
Georgia	Y	List of forecast for next 3 days	Travel information	N
Hawaii	N	-	-	-
Idaho	Y	Listed conditions for roads under map	Winter driving	Map of road conditions for different roadways
Illinois	N	-	-	-
Indiana	N	-	-	-
Iowa/Iowa 511	Y	Forecast on homepage by weatherview	Homepage	N
Kansas	Y	RWIS map with weather info by station	Road Weather Information	Map of weather stations
Kentucky 511	N	-	-	-
Louisiana	N	-	-	-
Maine 511	Y	Text when click on map symbol	Weather forecasts	N
Maryland	Y	List of forecast for next week	CHART → Local Weather conditions → Current Conditions	Forecast icons
Massachusetts	N	-	-	-
Michigan	N	-	-	-
Minnesota/Minnesota 511	Y	Click on area and get forecast	Weather tab	N

State/Provider	Daily weather update	Daily weather update format	Daily update page	Daily update media
Mississippi	Y	Temps at top of traffic page and radar weather page	Traffic and weather pages	Moving radar map by accuweather.com
Missouri	N	-	-	-
Montana	Y	List of forecasts on weather site, also road weather conditions and image given on RWIS text page	Weather	Image of road conditions
Nebraska/Nebraska 511	Y	List of links to websites with forecasts	Weather	N
Nevada 511	Y	Temperature, wind, and weather maps	511 homepage	Maps
New Hampshire	Y	Forecasts for different locations	Weather links	Icons for weather events
New Jersey	N	-	-	-
New Mexico	Y	Links to weather sites	Roads and Traffic	N
New York 511	N	-	-	-
North Carolina	N	-	-	-
North Dakota	Y	Weather radar on map	Travel information map	Moving radar
Ohio	Y	Table of weather info for each sensor	RWIS link from text version of map on buckeyetraffic.org	N
Oklahoma	y	Current info on Oklahoma Mesonet	Oklahoma Mesonet	Maps
Oregon	Y	NOAA forecasts below map	Under weather outlook tab	Map of location of forecasts
Pennsylvania 511	Y	Weather forecast by county	511 Weather forecast	Weather icons
Rhode Island	Y	Weather forecasts	511 page	N
South Carolina	N	-	-	-
South Dakota	Y	Forecast and observation maps	Homepage of safetravelusa.com	Maps
Tennessee	N	-	-	-
Texas	N	-	-	-
Utah	Y	Icons to mouse-over on the maps page and text list of weather conditions	Weather report and map pages	N
Vermont 511	Y	Weather station icons on map	Map page	N
Virginia 511	Y	NOAA forecasts on page, also weather related road conditions in table	Weather page	Weather icons
Washington State	Y	Weather map with icons and text by clicking	Weather page	Map
West Virginia	N	-	-	-
Wisconsin 511	Y	NOAA link and RWIS map on DOT site with info at stations	RWIS	No

State/Provider	Daily weather update	Daily weather update format	Daily update page	Daily update media
Wyoming	Y	Observed temperatures, radar, and weather maps	Condition maps	Map
Accuweather	Y	Weather forecasts	Search by location	Icons and maps
BBC Weather	Y	Weather forecasts	Search by location	Icons
Intellicast	Y	Weather forecasts	Search by location	Icons and maps
Met Office	Y	Weather forecasts	Search by location	Icons
National Weather Service	Y	Weather forecasts	Search by location	Icons and maps
Weather Underground	Y	Weather forecasts	Search by location	Icons and maps
Weather.com	Y	Weather forecasts	Search by location	Icons and maps
Weatherbug	Y	Weather forecasts	Search by location	Icons and maps