**Traffic Control Devices Pooled Fund Study**

# Warning Sign Legends for Emergency Incidents

Final Report

To:

Federal Highway Administration
1200 New Jersey Avenue, S.E.
Washington, DC 20590

By:

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# Foreword

The objective of the Transportation Pooled Fund Program's Traffic Control Device (TCD) Consortium is to assemble a consortium of regional, State, local entities, appropriate organizations and the FHWA to 1) establish a systematic procedure to select, test, and evaluate approaches to novel TCD concepts as well as incorporation of results into the MUTCD; 2) select novel TCD approaches to test and evaluate; 3) determine methods of evaluation for novel TCD approaches; 4) initiate and monitor projects intended to address evaluation of the novel TCDs; 5) disseminate results; and 6) assist MUTCD incorporation and implementation of results.

This report documents efforts to identify and evaluate general message options for Traffic Incident Management (TIM) TCDs like advance warning and guide signs. Multiple methods were used to identify message options. Data from this project show the extent that select messages from the MUTCD, the EU and a selection of novel messages can be associated with traffic incidents and proper driver actions.

Information from this study may be of interest to local, regional, state and federal agencies that regulate and provide guidance for traffic incident management. Signing engineers, other researchers, practitioners, and decision makers who are concerned about providing clear messages to drivers who are approaching a traffic incident may also be interested in this study.

Monique R. Evans
Director, Office of Safety
Research and Development

## Notice



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16. Abstract

The objective of this project was to identify general message options for Traffic Incident Management (TIM) traffic control devices (TCDs) like advance warning and guide signs and for showing on variable message boards (VMS). General messaging could allow for a smaller number of suitable TCDs for the many different types of incidents that occur while also satisfying the need responders have for carrying a small amount of traffic control equipment (e.g., responders' vehicles have storage limitations). There are a large number of potential messages available to first responders but minimal guidance for selecting legends and symbols that are effective. A goal for this research is to provide information for updates to guidelines on TCD legends and symbols (e.g., the Manual on Uniform Traffic Control Devices (MUTCD).

This project involved the following four tasks: 1) first, a literature and practice review was completed to catalog and review available documentation on TIM; 2) then subject matter expert (SME) were interviewed to learn more about TIM operational aspects directly from practitioners; 3) this was followed by a series of brainstorming sessions with first responders and people from the general public that were asked to generate novel traffic legends and symbols; and 4) the final task was a comprehension study on novel and existing traffic legends and symbols.

The results of this project indicate that TIM consists of numerous activities that are dissimilar from traffic management for planned traffic events (e.g., construction). The information from the SME interviews and focus groups indicate that there is a large degree of variability in how and when responders are notified of traffic incidents; the availability of resources in personnel and equipment depends on budgets that can be severely constrained; the time requirements and the methods that are used for installation and removal of TTC depend on the incident, and numbers of staff equipment; and the personnel providing traffic control can vary depending on who is closest to the incident, when it happens and its severity (e.g., police, fire, fire-police, or response technicians may be first to respond).

The comprehension study tested novel messages generated by incident responders and the general public, as well as standard messages from guidelines documents. The results showed that many of the novel messages generated by the focus groups were well understood and that there may be many more useful legends and symbols than previously recommended in the MUTCD that could be used for TIM.

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## SI* (MODERN METRIC) CONVERSION FACTORS

### APPROXIMATE CONVERSIONS TO SI UNITS

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

### APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

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# List of Acronyms and Abbreviations

AASHTO ..... American Association of State Highway and Transportation Officials
CEDR ..... Conference of European Directors of Roads
CMS ..... Changeable Message Sign
EMS ..... Emergency Medical Services
ETC ..... Emergency Traffic Control
FHWA ..... Federal Highway Administration
FHWA ..... Federal Highway Administration
GDOT ..... Georgia Department of Transportation
GP ..... General Public
IR ..... Incident Responder
IRB ..... Institutional Review Board
IU ..... Information Unit
MDOT ..... Michigan Department of Transportation
MUTCD ..... Manual on Uniform Traffic Control Devices
MUTCD ..... Manual on Uniform Traffic Control Devices
NFPA ..... National Fire Protection Association
PVMS ..... Portable Varable Message Sign
TCD ..... Traffic Control Device
TIM ..... Traffic Incident Management
TIMA ..... Traffic Incident Management Area
TMC ..... Traffic Management Center
TRID ..... Transport Research International Documentation
TTC ..... Temporary Traffic Control
VMS ..... Variable Message Sign
VSL ..... Variable Speed Limit
WaTIMCo ..... Washington Traffic Incident Management Coalition
WisDOT ..... Wisconsin State Department of Transportation
WSDOT ..... Washington State Department of Transportation

# EXECUTIVE SUMMARY

## BACKGROUND

Advance warning and guide signs are types of Traffic Control Devices (TCDs) that have the potential to inform drivers of incidents that they are approaching and providing guidance on an appropriate diversion. The content of legends for TCDs for traffic incidents is the topic of this research project. There are a large number of potential legends and symbols available to first responders to use for providing messages to drivers across the large number of different types of traffic incidents that occur. However, emergency responders can only select a small set of because of the limited amount of traffic control equipment that they can fit in their vehicles. There are guidelines for the design and use of general TCDs (e.g., the *Manual on Uniform Traffic Control Devices* (MUTCD [13]). However, these guidelines need to be updated to reflect traffic incident responder limitations.

## OBJECTIVE

The objective of this project was to identify message options for Traffic Incident Management (TIM) that can be used to create TCDs (e.g., advance warning and guide signs) that are useable considering vehicle storage limitations, and other incident response constraints. We used a multi-staged approach to identify message options for TIM TCDs.

## PROJECT OVERVIEW

This section provides an overview of the overall project. A review of current practice and available literature was completed, followed by interviews with subject matter experts and focus groups with incident responders and the general public. Each of these efforts led to identifying legends and symbols tested in a comprehension test. Project tasks are described below.

**State of Practice Review and Literature Review:** Information from traffic incident management guidelines and practice documents were reviewed and synthesized (The literature is summarized in Table A1 in Appendix A). The literature shows there is a large number of TCDs that are available for traffic incident management, but inadequate funds lead to inadequate quantity of staff to install and remove temporary TCDs at incidents. Some progress has been made in enhancing traffic control capability. For instance, a pilot program led to equipping fire response vehicles with compact kits for providing traffic control at traffic incidents. In general the available documentation on traffic incident management suggests that current guidelines (e.g., Chapter 6i of the MUTCD) for setting up traffic incident management areas may not align perfectly with actual field practice and agency response capability. There was not much literature about legends and symbols for temporary traffic control devices for traffic incident management.

**Subject Matter Experts (SMEs) Interviews**: A group of nine incident response experts were identified and interviewed. Interviews with SMEs focused on the traffic incident management process and their responses provide insight on operational aspects of traffic control for traffic incidents. The SMEs often stated that many of the messages that are currently in use may be

adequate. However, they expressed a need for general messaging; whether from the existing set or if they are novel, responders do find value in messages that could be used across the many different incidents that occur on our roadways.

There are multiple agencies (e.g., police, fire, fire-police, and incident response technicians) that respond to traffic incidents and each agency has different capabilities, which results in higher variability in actual response practices nationwide. This non-uniformity should be recognized when developing standards and best practice documents. Additionally, the majority of incidents in some regions are non-major, lasting for brief periods of time, but most of main guidelines documents (e.g., MUTCD chapter 6i) are written for major incidents. This can cause a problem for agencies building up their response capabilities when their governing bodies abide by guideless that are not representative of the common incidents in their region.

**Focus Groups:** The focus groups were brainstorming sessions during which participants (eight incident responders, and fourteen people from the general public) shared their ideas for traffic control legends, symbols, designs, and placement relative to the incident. Traffic incidents were simulated using a low-fidelity table-top method that consisted of poster-sized aerial images of roadways and a fleet of vehicle miniatures that were used to act out eight different traffic incidents. Participant responses were quantitatively evaluated by objectively comparing them to guidelines on information content for traffic messaging (e.g., Dudek [9]). Their discussions were recorded and summarized.

The focus group results contained a large number of brief messages to guide drivers away from an incident. Also common was the notion of diverting drivers as far upstream before the incident location as possible. There was discussion regarding the use and value of general messaging (e.g., EMERGENCY SCENE AHEAD) from which the general public showed a high degree of acceptance and understanding. Symbolic messages were considered useful to prevent drivers from spending too much time looking at the message and away from the roadway. There were a few traffic management issues that were discussed that did not lend to an obvious preventative or mitigating solution (e.g., preventing drivers from rubbernecking and gawking may prove difficult). A select set of message ideas from the focus groups were evaluated in the comprehension study.

**Comprehension Study:** All test messages were selected based off of the responder needs identified in earlier efforts (e.g., SME interviews, and focus group discussion). Some message ideas from the focus group, as well as a large set of legends and symbols from the MUTCD and those used in the European Union were included in the comprehension study. There were two goals supporting the comprehension study, one goal was to identify a generalizable set of traffic incident messages that drivers comprehend as signifying a traffic incident. The second goal was to evaluate a sub-set of traffic incident messages to gain insights on the driver actions they promote. Two studies were carried out to accomplish our evaluation goals.

The results of both studies show that concise language can be effective at getting drivers to associate a traffic control legend with a traffic incident. Legends and symbols may be associated with traffic incidents with less consistency if they are not clearly marked with a concise phrase or term to indicate there is a traffic incident. There may be a high degree of association between traffic roadway messaging and road construction, but we conclude that the association is

justifiable given the critical similarities between road construction and traffic incidents; in both cases there are personnel that are exposed to traffic.

An exclamation mark was associated with traffic incidents more often compared to all other messages that were tested, which suggests its use in traffic incident management may be appropriate. A Prohibitory forward travel symbol (i.e., MUTCD R3-27) was reliability associated with traffic incidents, the results for this symbol also imply that it could lead to drivers reroute themselves without additional guidance, which is a need mentioned by SMEs and responders. To the extent that enhancing awareness of delays is needed, the precise language in the legend may be of secondary importance as there was a strong tendency in this study to associate most of the tested legends and symbols with delays.

## CONCLUSIONS

Traffic incident management consists of numerous activities that are likely dissimilar from traffic management for planned traffic events. For traffic incidents there is a large degree of variability in how and when responders are notified of the event; the availability of resources in personnel and equipment depends on budgets, which can be severely constrained; the time it takes and the methods that are used for installation and removal of TTC depend on availability of staff and equipment, which is often low; and the types of personnel providing and responsible for traffic control can vary depending on who is closest to the incident, when it happens and its severity (e.g., fire, or police, or fire-police, or response technicians).There may be useful legends and symbols in the MUTCD that were not previously considered that could be included in guidelines for traffic incident management. Responders recognize the value of traffic control and state that it would be more common if the logistical issues were resolved.

## KEY RECOMMENDATIONS

The results from this project allow the following recommendations for future editions of the MUTCD or other guidelines for traffic control for traffic incidents:

- Separate traffic control regulation, guidelines and standard best practice for TIM from all other forms of traffic control.
- Require the use of TTC devices that can be removed from an incident without placing personnel in travel lanes; an option for this could be to recommend the use of flares for creating traffic tapers, which can then be left to burn-out.
- Require legends to contain concise language or symbols that can be quickly viewed by road-users.
- Include the following terms as acceptable descriptors of incidents: CRASH AHEAD, INCIDENT MANAGEMENT, FIRE ACTIVITY, and TRAFFIC EMERGENCY AHEAD.
- Include MUTCD R3-27 (i.e., the prohibitory forward travel symbol) as a potential for traffic incident management rerouting.
- Include the EU exclamation mark as a potential symbol for representing a traffic incident.
- If a reverse curve is used, the addition of a representative symbol (e.g., “X”) can be used to enhance the association between the legend or symbol and the incident.

# CHAPTER 1. INTRODUCTION

## BACKGROUND

Emergency personnel that are first to respond to traffic incidents may have to provide traffic control. Incidents like disabled vehicles, hazardous material spills, fires, and vehicle collisions can vary in duration, severity and their impact to road users. For instance, a materials spill may block several travel lanes and require several hours of work for cleanup, leading to road closures, extensive traffic control and the need for traffic to be detoured. There is a high degree of time criticality for establishing traffic control to minimize the impact the incident causes on traffic flow. After first responders assess the incident, if they are to install traffic control devices, they must select the type of information to communicate to road users, which they try to accomplish within minutes. Ideally, the installation of temporary traffic control would ensure the safety of emergency responders as they complete their work at the incident scene. Advance warning and guide signs are types of Traffic Control Devices (TCDs) that have the potential for informing drivers of incidents they are approaching, and then guiding them around the incident. The content of messages for traffic incidents is the topic of this research.

There are guidelines and standards for the design of traffic control signs. The *Manual on Uniform Traffic Control Devices* (MUTCD [13]) states that warning and guide signs for temporary traffic control should have a black legend, black border and an orange or fluorescent pink background. MUTCD also contains suggestions for message content. Manufacturers produce signs that are compliant with MUTCD but have a variety of verbal and symbolic elements. Potentially, there are a large number of different signs available to first responders to use for the diversity of incidents they encounter. However, emergency responders are severely limited in their use of temporary traffic control devices due to limitations in the amount of equipment that they can carry along with when responding to an incident.

## OBJECTIVE

The objective of this project was to identify message options for Traffic Incident Management (TIM) signs (e.g., advance warnings and guide signs) that are used to help notify drivers of incidents and proper driving actions. A specific goal was to identify a set of versatile messages for traffic incidents that could be used by first responders. This versatility may result in messages that are useful as traffic control devices multiple incidents due to clearer conveyance of pertinent information to oncoming traffic. It seems reasonable that messages that are non-specific about an incident but that convey minimal relevant information to drivers may be easier to deploy for multiple incident types.

There are two elements of information to deliver to drivers: 1) clearly communicate risk, and 2) inform of a correct course of action. As outlined below, we used a multi-staged approach to identify options for TIM traffic control messages.

## PROJECT TASKS

There were six project tasks, including the Kickoff meeting. Project tasks are conceptually grouped into task types in Figure 1. Within this conceptual grouping, during Tasks 1 through 3

identified problems, scenarios and signs that relevant to traffic incident management. The information from the first block of tasks informed our methodological considerations for Task 4, which identified useful sign messages using focus groups. A selection of these sign messages were evaluated toward the end of the project during Task 5. All task reports and the results of Task 5 are combined and included the final report.

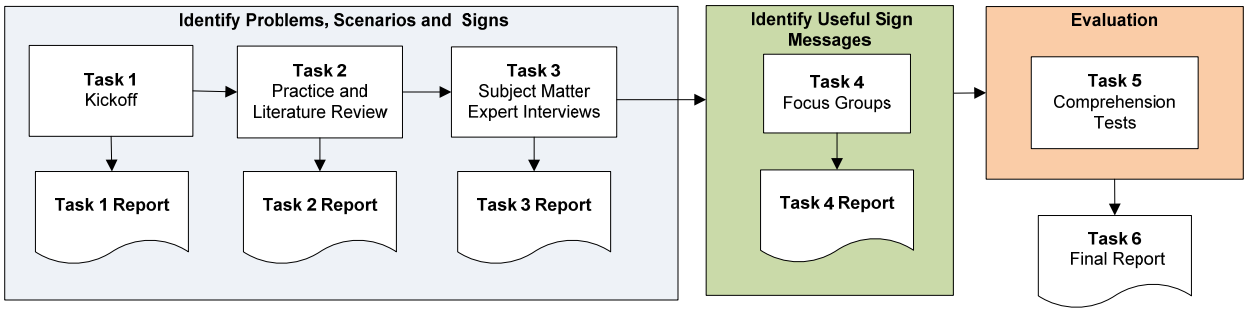



**Figure 1. Conceptual grouping of task types.**

## OVERVIEW OF THE REPORT

This report provides a description of the tasks, activities and results of the state of practice and literature review, interviews with SMEs, focus group interviews, and comprehension study. The remaining report contains the following 4 chapters that discuss the technical activities of this project:

- Chapter 2: Task 2 – State of Practice Review and Literature Review
- Chapter 3: Task 3 – Interview SMEs
- Chapter 4: Task 4 – Focus Group Interviews
- Chapter 5: Task 5 – Comprehension Study

The technical chapters are followed by a chapter titled Conclusions and Recommendations. Appendices are also included.

# CHAPTER 2. LITERATURE REVIEW

## METHODS

The following activities were completed to provide a review of practice and literature: 1) a *literature search* was conducted to find current, relevant and publically available sources, and 2) a *synthesis of literature* was conducted during which the results, findings and information on general practices were combined in a coherent manner.

### Literature Search

Given the exploratory nature of this project, we did not expect to find more than a few research sources that were directly related to traffic control devices (TCDs) for emergency traffic incidents. A series of searches were completed using combinations of logical keywords. All literature searches were conducted using the TRID (Transport Research International Documentation) database search tool and Google Scholar. Additionally, websites for traffic incident management agencies were also examined to find relevant practice and literature documents. The initial literature and practice document searches were conducted using search terms extracted from key source documents (e.g., WisDOT [29]; Delcan & GDOT [8]). This was an opportunistic search process. Keyword searches that resulted in one or more relevant documents are listed in Table 1.

**Table 1. Search terms used for literature searches and websites with practice documents.**

| Search Number | Index | Keyword Search Terms |
|---|---|---|
| 1 | TRID | (“Traffic Incident Management” OR “First Responders” OR “Secondary Crashes” or “Incident Response Program” OR “Freeway Incident Management” or “Incident Responders” OR “Emergency Responders” OR “Emergency Rerouting”) AND (“Traffic Control Devices” OR “Advance Warning”) |
| 2 | TRID | MUTCD” AND (“Traffic Control Devices” OR “Advance Warning Signs” OR “Temporary Traffic Control”) |
| 3 | Google | "Secondary Crashes" AND "Advance Warning Signs" |
| 4 | Google | "Traffic Incident Management" AND "Secondary Crashes" AND "Traffic Control Devices" |
| 5 | Google | "Traffic Incident Management" AND "First Responders" and "Advance Warning" |
| 6 | Google | "Traffic Incident" AND "Temporary traffic control" |

Websites were searched using a manual process. There were no keyword searches completed within these sites. The sites are listed below:

- AASHTO National Traffic Incident Management Coalition: http://ntimc.transportation.org
- Emergency Responder Safety Institute: http://www.respondersafety.com

- Traffic Incident Management Knowledgebase: http://ops.fhwa.dot.gov/eto_tim_pse/preparedness/tim/knowledgebase/

### Synthesis of Literature

Information from traffic incident management guidelines and practice documents were considered together as a whole. This information was then grouped into two general topics: *Traffic Incident Management Practice* and *Literature*. The Traffic Incident Management Practice information was grouped into sections that describe general practice and policies that may impact traffic incident management. The Literature topics reviewed research that has been conducted on traffic incident management, as well as research conducted on general message comprehension.

## LITERATURE REVIEW RESULTS AND DISCUSSION

This section contains a synthesis of the topics that were prevalent across the reviewed documents. Relevant documents and short reviews of them are listed in Table A1 in Appendix A. There are two main sub-sections in the Results and Discussions. The first is about *Traffic Incident Management State of Practice*, which includes discussion on practice in both the United States and in Europe. The second section is a *Literature Review* that covers relevant aspects of the research documents that were reviewed.

### Traffic Incident Management (TIM) State of Practice

This section reviews TIM practice in the United States and Europe. Many of the programs in the United States have been influenced by practice in Europe. Practice in the United States is discussed first, followed by European practice.

#### *TIM in the United States*

A traffic incident is defined in the MUTCD [13] as a roadway event that affects or impedes the normal flow of traffic. TIM is when temporary TCDs are used in response to a traffic incident. The MUTCD [13] provides general guidance for traffic control for roadway incidents (e.g., MUTCD chapter 6 section I-1). Other documents that provide additional and more specific guidance on what signs to use and where to place them are also available. Two such documents were reviewed for this report: the *Georgia Traffic Incident Management (TIM) Guidelines* [8], which was published by the Georgia Department of Transportation (GDOT), and *Emergency Traffic Control and Scene Management Guidelines - version 2.0* published in 2012 by the Wisconsin Department of Transportation (WisDOT). Information from the MUTCD, both of these documents and other sources are used to frame-up TIM practice in the United States for the purpose of this project.

### Signs and TTC in the United States:

The MUTCD provides examples of the types of signs that could be used for general traffic control. There is a notion that the signs that are used for general traffic control are adequate for emergency traffic incidents like vehicle collisions, hazardous material spills, natural disasters,

unplanned events, etc. For example, the Washington State Department of Transportation (WSDOT) suggests that an MUTCD compliant work zone be installed for lane-blocking traffic incidents that last longer than sixty minutes [29]. And the Georgia DOT suggests the use of MUTCD Work Zone signs and TCDs under an assumption that since motorists are accustomed to work zone signs, Traffic Incident Management Areas (TIMA) and TCDs should be similar to avoid confusion [8].

There are two signs from the MUTCD that are suggested in the TIM guidelines developed by WisDOT and GDOT. One sign has the message "Be Prepared To Stop" (W3-4) and the other has a symbol that indicates a merge is required (W4-2). A third sign that is also suggested for use indicates "Emergency Scene Ahead" and is not in the MUTCD, per se. However, the design of this sign is compliant with MUTCD 2009 as it consists of the required diamond-shaped, fluorescent pink color and black border and legend. The "Emergency Scene Ahead" sign and message is specifically mentioned in the National Fire Protection Association (NFPA) standard for safety and health programs (NFPA 1500 section 8.7.5). These signs are depicted below (Figures 2 through 4). Unfortunately, we were unable to find information on how effectively any of these three signs facilitate TTC for TIM.


**Figure 2. MUTCD W3-4 [8, 24]**

**Figure 3. MUTCD W4-2 [8, 24]**


**Figure 4. NFPA 1500 [8, 24]**

GDOT recommends that "special attention is paid to the end of the traffic queue" at a sufficient distance to allow motorists to slow before reaching the queue, guidance on what sign or signs to use is not too clear [8]. They also suggest that the placement of any sign be strategic to avoid sign clutter, but there is no clear guidance on how to place signs to avoid clutter. In addition, figuring out where a queue warning should be placed is no easy feat. The placement of a queue warning may require precision or drivers are likely to disregard it entirely, too close and drivers will not be able to respond in time, too far and drivers will find it irrelevant or incorrect. Placing the sign at a useful location is further complicated by the constantly changing nature of traffic queues [28].

The risk of secondary incidents up-stream (e.g., a rear-end crash queued traffic) is a problem that occurs in addition to the risk of secondary incidents at the primary traffic incident scene (e.g., vehicle intrusion). Although there are multiple methods for notifying drivers of forward traffic queues there is a practical limitation. There is rarely adequate staff available to respond

to an incident to place basic TCDs at the incident let alone additional up-stream TCDs that require continual monitoring or repositioning. Adequate response staff is a major factor when responding to traffic incidents. There is not often enough "man-power" to set-up a traffic incident area as per guidelines or recommended practice (e.g., McCormack, Walton, & Agent, 2011[19]). The extent that the amount of responding personnel is an issue is not typically discussed in available practice documents. An in-adequate number of response staff is a major obstacle that hinders the ability to deploy recommended TCDs in a consistent and effective manner at traffic incidents. This is an implication worth verifying and including with recommendations for traffic incident management.

**Rerouting for TIM in the United States:**

Rerouting traffic onto surrounding roadways rather than around the incident is sometimes required for traffic incidents. Providing a reroute for traffic requires a large staff of trained personnel, which is a cause for limited use for traffic incident management [18]. The Michigan Department of Transportation (MDOT) published a best-practice reference for traffic rerouting in 2012. The reference promotes MUTCD general guidelines, and it also provides guidance on the deployment and usage of signs for rerouting (e.g., TTC signs for rerouting should be covered when not in use and any short-term traffic control signs should be removed after use).

Rerouting traffic is recommended for longer duration traffic incidents as indicated by the MDOT 2012 best practice reference. Rerouting is not recommended for incidents of 30 minutes or less. If an incident is over one hour or estimated to be longer than an hour, then law enforcement should be deployed to reroute traffic in some manner. More elaborate rerouting is suggested for longer duration incidents, which may require the assistance of multiple agencies. It remains unclear how these durations are measured during an incident and how responders predict the duration of an incident, that is if they predict the duration at all.

**Policy and Law that Affects TIM in the United States:**

Certain traffic laws may provide assistance for agencies responding to traffic incidents. For example, many states have legislation requiring drivers involved in minor property damage to immediately move their vehicles from traffic lanes (e.g., *Steer it and Clear it Law* in Montana, Texas, South Carolina, etc.).

Most states in the United States (all except for Hawaii and Washington DC) have legislation requiring motorists to slowdown or move into adjacent lanes when approaching authorized emergency vehicles that are attending to traffic incidents (http://www.moveoveramerica.com/). These are known as *Move-over Laws*. Wisconsin passed a Move-over law in 2001, which calls for driver fines of $249 and demerit points against their license [24]. Not all drivers comply with the law but additional procedures can be used to urge motorists to merge appropriately. For example, emergency lights seem to help. Motorists may be more likely to comply with the move-over law when the lights on-top of responding emergency vehicles are active, this is with or without the addition of amber directional lights. Interestingly, driver compliance has been shown to be lower when only directional amber lights are used [4]. One issue related to lighting is the inference that emergency vehicle lighting functions only to warn drivers and provides no

effective traffic control and that vehicle lighting can be reduced when a proper traffic incident management area is established (see WisDOT [29]).

### *TIM European Practice*

There are similarities between TIM practices in the United States and TIM in many European countries. Perhaps the similarities are a direct result of the recommendations based on European practices that were published by the Federal Highway Administration in 2006 as part of their *scanning study* [17]. The scanning study was conducted by a team of interviewers who met with representatives from four European countries, which were England, Germany, the Netherlands and Sweden. The team interviewed representatives from over 30 different city, regional, and national organizations. These were organizations like police, fire, and emergency medical services, and auto clubs. The recommendations from the scanning study were:

1) To establish programs for traffic incident management (e.g., the National Unified Goal, performance measures, training, identifying private sector roles, etc.).
2) Improve communication across responding agencies (e.g., information centers).
3) And, improve on-scene operations (e.g., establish incident command, create a buffer zone, increase the visibility and position of response vehicles, etc.).

The tactical and operation recommendations for on-scene operations are the most relevant to the current effort. One simply stated but perhaps idealized goal for traffic incident management is to place highest priority on reducing the impact of the incident on traffic flow and roadway capacity, which is something that could be accomplished with adequate signage. This is a notion that is carrying over to the United States.

**European Signs and TTC:**

An *End of queue advance warning* is used in German speaking European countries to indicate to drivers that they are approaching a traffic jam. The warning is simply a sign that says “Stau” which translates to “Backup” or “Traffic Jam”. The sign is also mobile in order to accommodate the frequently changing length of vehicle queues. The sign is placed in advance of the traffic queue, which may be quite far from the location of the incident zone.

Providing drivers an advanced end of queue warning seems promising for reducing up-stream secondary crashes. Traffic queues have been known to increase the occurrence of secondary incidents. When the “tail” of the queue extends further upstream from the incident location the locations where secondary incidents can occur also extends [6]. A novel European approach for increasing awareness of a traffic queue is to require other drivers who are traveling on the same roadway and approaching the incident to activate their hazard lights. This is mentioned as a best practice by the Conference of European Directors of roads but it is not clear how it is carried out, or if it is merely a courtesy of motorists that has been picked-up on and simply mentioned in guidelines [6].

Certain TCDs may also be useful for reducing the likelihood of secondary incidents. A Variable speed limit (VSL) can be used to reduce the speed of upstream traffic [17]. The extent that VSL can be similarly deployed using temporary traffic signs has not been fully explored for the short-term traffic incidents we are interested in for this project. Temporary speed reduction for

construction is fairly commonplace in the United States. Speed related crashes are still rather problematic in construction zones [21].

When other types of TCDs fail at keeping traffic moving efficiently, it may prove helpful to block approaching drivers' view of the incident. European best practice suggests the use of *incident screens* to block the view of passersby and this has been shown to reduce driver slowdown that would otherwise result from gawking or rubbernecking. Incident screens are large opaque barriers that are placed around a traffic incident scene [6].

**Rerouting for TIM in Europe:**

There is established best practice in Europe for rerouting traffic away from or around incidents. A few notable techniques that are included in guidelines for European practice are listed below:

- *Rolling Back/Convoy Control* – "traffic-free windows" of specific length are created by placing a responder downstream with a stop-sign that is used to release traffic for specific intervals to create traffic-free gaps or windows;
- *Hard Shoulder Running* – using the shoulder as a lane for traffic;
- And, *Rearward Relief* – allow trapped motorists to turn around and go the "wrong" direction down the highway toward a junction where they can reroute.

**Setting up TIM**

It is important to ensure that practice guidelines and requirements align with what is achievable with the quantity of responding staff, available equipment and the capabilities of the people responding to the traffic incident. Although guidance is available (as discussed above) and many responders are trained in how to respond to traffic incidents, it is not always practical for responders to set up TTC at a traffic incident as per the recommendations or guidelines. Quantity of responding staff and equipment is often inadequate [1]. The cost of temporary TCDs can also limit the type and amount of equipment responders have available when they respond [24].

McCormick, Waldon, and Agent [19] reported on a pilot study about firefighters' use of emergency traffic control (ETC) kits that contained the necessary equipment to safety install traffic control at a traffic incident (e.g., cones, an NFPA 1500 compliant advance warning sign, stop/go paddles, retroreflective vests). The kits were designed to be compact enough to fit on a fire truck, but the results indicated that there were significant space issues that required the fire truck personnel to exercise their ingenuity to store the equipment. Some fire agencies placed parts or all of the ETC kit in separate response vehicles that were called to the site if traffic control was needed.

Training is a key factor in the successful application of the TIM guidelines. Training on the use of basic procedures for ensuring the safe movement of traffic is rarely provided to first responders and training on how to set up a traffic incident management area is not provided to absolutely all persons who respond to an incident, like fire personnel. In order to complete their evaluation of a novel *emergency traffic control kit,* McCormack, Walton and Agent [19] had to establish a method to deliver existing training to first responders before they used the kits.

## LITERATURE REVIEW CONCLUSIONS

The findings from the literature review conducted in the current task suggests that the guidelines that are available to first responders for setting up traffic incident management areas may not align perfectly with actual field practice. These guidelines may not provide all the information and considerations for the diverse situations that first responders may encounter when responding to actual traffic incidents.

# CHAPTER 3. SUBJECT MATTER EXPERT INTERVIEWS

Information from SMEs is essential for putting TIM issues in proper context and to scope the field of investigation to issues of highest priority. Our goal was to identify the road-users and incidents of the greatest concern or most frequently encountered. Interviews with SMEs focused on the traffic incident management process. There were several key questions included in our interviews:

- Who places the TTCs in the roadway (e.g., EMS, police, fire department)?
- When and how is traffic management impacted following an incident?
- What are the challenges to traffic incident management?
- What are the key incidents for which signing would be or is helpful?
- What driver behaviors/modifications are central to successful traffic management?

Identifying and making contacts with SMEs was a major task that that was critical to achieving success with this project. We identified a group of notable SMEs and used a procedure to ensure maximum value from each interview. Specifically, our goal for each SME interview was to obtain as much novel and insightful information as possible for use in the focus group and comprehension studies in Tasks 4 and 5. To accomplish this we used the methods described below.

## METHODS

The SME interview methods are described below and included the following: 1) *Recruitment Activities*, 2) *Conducting Interviews*, 3) and the procedure we used to *Reduce Interviews into Content.*

### Participants

A list of SMEs was assembled prior to the start of recruiting. The list initially consisted of SMEs provided by FHWA and the Traffic Control Devices Pooled Fundy Study members. In addition, we recruited authors and consultants whose contact information was available in the documentation that we reviewed for the Task 2 literature and practice review. We were also provided with additional contacts referred by SMEs on our list.

Our recruitment process started with an email from either the FHWA project COR or from Battelle staff. In total, we emailed twenty-two prospects. The emails included the text shown in Appendix B. Table 2 shows the job titles of the nine SMEs that we interviewed.

**Table 2. Subject matter experts' (SMEs') job titles.**

| Interview Order | Job Title |
|---|---|
| 1 | Director of Emergency Responder Training |
| 2 | Fire Fighter Association President and TIM Coalition Chairman |
| 3 | Transportation & Emergency Management Manager |
| 4 | State Signing Engineer for Division of Transportation Infrastructure Development |
| 5 | State Work Zone Traffic Safety Engineer |
| 6 | Freeway Operations Supervisor at a Regional Transportation Management Center |
| 7 | President of Fire-Police |
| 8 | Fire-Rescue Deputy Chief |
| 9 | Chief Technical Sargent for Police |

### Procedures

Interviews were conducted from November 2013 to early February 2014. Each interview was conducted via teleconference. The same person acted as the moderator for all of the interviews (Graving, J. S.) and short-hand notes were taken during each interview by a trained observer (Bacon, L. P.). An audio recorder (Audacity ® 2.0.5) was used to record each interview. The audio recordings were used for clarification purposes. The recordings were deleted at the end of this project (September, 2014).

Although the interviews were principally unscripted, as they were carried-out in an open forum, an interview moderator guide was used to introduce the topic and for initial questioning. The moderator guide is shown in Appendix C. The majority of interview questions were improvised and rooted in the discussion topics that resulted from initial questioning. Neither the interviewer nor the participants were fixed to a rigid agenda of topics or questions. As a result of the highly flexible approach we were able to expand on relevant discussion points that arose, or move the discussion away from topics that were less fruitful. The free-form structure of the interviews may have contributed to the richness of the information that our SMEs provided.

### Analysis

The short-hand notes and audio recordings were reviewed. Segments of lengthy interview discussions were reduced down to their useful content (i.e., the gist of what was being said ended up in the results). In addition, in many cases a single topic was discussed at various times during an interview; topics like this were combined into a single sentence or paragraph in the *Results and Discussion* section.

## SME INTERVIEW RESULTS AND DISCUSSION

Relevant findings from the TIM SME interviews are summarized below. The interviews provided insight on issues regarding messages for traffic control and for providing drivers advance warning of an incident.

Most of our SMEs indicated that their policies and procedures are based around the content of the MUTCD. The definition of a traffic incident in Chapter 6i of the MUTCD is quite general but provides a useful distinction in that traffic incidents are unplanned events, "A traffic incident is an emergency road user occurrence, a natural disaster, or other unplanned event that affects or impedes the normal flow of traffic" [13]. Examples of specific traffic incidents as mentioned by our SMEs are listed below:

- Heavy rain
- Forest fire
- Pavement blow-up/buckle
- Flash flooding lasting 3 days to 2 weeks
- Truck flipping over and blocking all the lanes on a highway
- Plane crash on a roadway
- Oil leak from a building

There certainly are more types of incidents that could be listed had we talked with more SMEs. The MUTCD does not provide a lot of guidance non-major incidents, which tend to be the most common—e.g.:

> *"Chapter 6i of the MUTCD provides useful guidance for incidents like hurricanes or floods and long duration incidents. In most cases traffic incidents are not over 2 hours. The most common incidents are around 30 minutes."* [Interview 5]

From the incidents listed above, it becomes evident that traffic incidents may occur on many types of roadways. There is further specification provided in Chapter 6i of the MUTCD, which indicates that incidents that require TCD installation occur on the *highway* as per the description of a Traffic Incident Management Area (TIMA).

> A TIMA is an area of a highway where temporary traffic controls are installed, as authorized by a public authority or the official having jurisdiction of the roadway, in response to a road user incident, natural disaster, hazardous material spill, or other unplanned incident. It is a type of temporary traffic control zone and extends from the first warning device (such as a sign, light, or cone) to the last temporary traffic control device or to a point where vehicles return to the original lane alignment and are clear of the incident [13].

The following sections of this chapter contain interview discussion points that are relevant to delivering messages to drivers. The SMEs discussed relevant TCDs and messages, the metrics they use to assess effectiveness (e.g., observations of driver behavior), and ideas for improving responders' ability to use TCDs when responding to incidents.

There are three main sections, the first provides information on *TIM Messages*, and the second provides information on *Traffic Control Devices (TCDs) and Installation Issues at Traffic Incidents*, with subsections on *Static Signs* and *Variable Message Signs*. A third section covers *Other TCDs*, with subsections on *Cones and Flares*, *Blocking Vehicles*, and *Non-vehicle Blockades*. The final section provides a short discussion on *Resources, Response Capability and Backup*.

**TIM Messages**

This section discusses messages that could either be presented on a static sign or an electronic sign, or other type of presentation medium.

A common topic that was discussed throughout the interviews was that the specific messages that are used are important for driver compliance with traffic control measures. There are numerous examples of messages that could be used at any number of incidents. The messages in the list below were discussed during our interviews. There are alternative resources for practitioners and responders to use when deciding on appropriate messages (e.g., Traffic Guidelines Manual for Portable Changeable Message Signs by WisDOT; and Guidelines for Changeable Message Sign Use by MNDOT).

The list below is only a partial list of messages that are available, but these were mentioned during the interviews with SMEs:

- BE PREPARED TO STOP
- BE READY TO STOP
- CRASH 1 MILE AHEAD LEFT LANE CLOSED
- CRASH 3 MILES AHEAD
- DANGER
- DO NOT PASS
- EMERGENCY AHEAD
- EMERGENCY SCENE AHEAD
- FIRE SCENE AHEAD
- INCIDENT AHEAD
- LIVE WIRES/ELECTRICAL HAZARD
- MERGE
- ROAD CLOSED AHEAD
- ROAD CLOSED LOCAL ONLY
- RAMP CLOSED
- SLOW
- TRAFFIC CONGESTION AHEAD BE PREPARED TO STOP
- TRAFFIC STOPPED AHEAD
- WATCH FOR STOPPED TRAFFIC

Readers should be aware that there is uncertainty behind the usage of DANGER as a message. One SME indicated it is an acceptable term while a different SME said that it is not; neither, however, provided a rationale. Similarly, there are instances when messages, which an agency decides are standard for a region (e.g., a state TMC's own list of acceptable messages), may not be deemed as favorable by the people actually responding to incidents. When this happens the responding staff will make requests to use what they think is appropriate. As indicated by a SME with a technical background and field experience:

> *"There are acceptable terms. But if the incident is something completely unique and I know those messages do not fit, I will let our TMC know that I need a one-*

*time adjustment. But, in my 14 years doing that we only made this type of request 2 or 3 times"* [Interview 9].

A potential reason for such infrequent changes to messages is the notion that standardization and driver familiarly increases comprehension. Standardization and familiarity have been found to be statistical predictors of driver comprehension of road signs (e.g., Ben-Bassat & Shinar, [2]; Ng & Chan, [22]). There is good reason to assume that standardization and familiarity apply to the use of general purpose messages (i.e., the use of a traffic control message for construction or other planned event may serve a useful function for an unplanned event like a traffic incident). Consistent and standard messaging might increase the likelihood drivers' pick-up the information that is being delivered—e.g.:

*"…keep messages consistent, whether it's a traffic incident, weather issue, planned or unplanned event. Getting at least one proper [common] message out there is key"* [Interview 9].

There are some examples of when drivers completely disregard DO NOT ENTER type messages, which is a scenario that provides an easy-to-observe method for determining how changes to this type of message affects driving behavior. In order to keep drivers from entering a blocked roadway, messages that reference other types of hazards are sometimes more effective at keeping people from by-passing a barricade:

*"On occasion, instead of putting up ROAD CLOSED when we want to totally block the road we put up ELECTRICAL HAZARD, DANGER, or LIVE WIRES and use cones or barricades to block the road. Drivers are less apt to move the barricades so they can drive through when they think there are downed live wires. We do things like this when don't have the manpower to put a person at the barricade"* [Interview 7].

It is worth briefly mentioning that people move TCDs out of their path of travel, which is not the intent of the responders who install the TCDs. Interview 7 also provided examples of other workarounds to keep drivers from moving traffic control barricades (e.g., *"…only blocking half of the road keeps people from moving our barricades"*). Barricades are discussed later.

Returning to the notion that TCD messages carry meaning that influences drivers' responses, the idea that drivers need to know the reason for traffic control was discussed by many of the SMEs we interviewed. The notion that providing drivers with some type of notification of the type of event that is causing the need for traffic control has some history in the literature, but the effectiveness of various message ideas may need further research. For example, in their work on highway work-zones, Dudek and Ullman [10] reported that ROAD WORK AHEAD was less effective than LANE BLOCKED at supplementing a cone taper with lane merger icons and messages. The essence of the effective but erroneous messages mentioned during Interview 7 is that it presents information that drivers might interpret as having higher personal relevance. Downed wires could be perceived as too risky to approach. Alternatively, driving around a work-zone might be perceived as predictably manageable and very low risk.

An intriguing but un-substantiated idea that was mentioned during an interview was that some general messages may serve to increase driver attentiveness—E.g.:

> *"INCIDENT AHEAD can be dynamic in getting drivers to pay attention. You don't give them all the information. When they start thinking, 'what's going on?' Then they will slow down because they don't know what's around the next bend or down the next hill, but they know something's up"* [Interview 3].

The next series of comments are qualitatively different but pertain to influencing driver attention through the use of standard TCDs. Some TCDs may capture the attention of approaching drivers. In reference to the recommended sign in NFPA 1500 section 8.7:

> *"The sign from NFPA 1500 gets peoples' attention, which is one of our biggest issues"* [Interview 1].

Similarly, there may be methods of deployment that can be used to influence driver attention. For example, messages can be repeated verbatim within an incident scene and by alternating the presentation format drivers may be more likely to receive the message:

> *"The message should be consistent because that's very important; it should be the same but presented multiple times and in different ways. One presentation method might be a pavement marking, another could be a variable message sign, and another could be a permanent sign. If people see the message 2 or 3 times it's going to register. It should be shown in a couple different ways to get them to see the message …same message but different modality"* [Interview 9].

Not everybody is certain about the usefulness of signs for influencing drivers' attention. This skepticism is rooted in the visibility of the scene itself. There is a practical notion that the emergency lights, and the size and color of the responding vehicles should be enough of a visual cue. But this has been faulted by SMEs because there are still secondary incidents. Visibility might not be the only factor. In-vehicle distractions may be a challenging contributing factor that signage may not readily solve, as is implied by this statement:

> *"You can put all the signs you want, but if we can't get the drivers to look out the windshield, it doesn't really matter. They are running into big red fire truck with brilliant yellow and lime green markings and flashing lights all over them, and saying 'gee, I didn't see them'"* [Interview 1].

There was general agreement among our SMEs who were from areas within the service of Public Safety (e.g., Fire, Fire-police, and Police) that the sign messages are of lower importance than how TCDs are deployed. Messages may be a secondary issue due to the complexity involved in installing equipment at an incident—e.g.:

> *"Tactics need to be ironed out before we worry about what the sign says. Signs are rusting because we aren't using them"* [Interview 9].

> *"…messages that are being pushed now serve our needs. I don't see any need to change them … but we need help and assistance in finding better ways to deploy the signs"* [Interview 1].

The remaining discussion and results presents issues regarding installation of TCDs at traffic incidents, message presentation options (e.g., static signs or variable message signs, etc.) and general resources.

## Traffic Control Devices (TCDs) and Installation Issues at Traffic Incidents

This section discusses TCDs that are used to display messages and the installation or deployment issues that are faced by first responders.

The TCDs used by emergency services during the initial response to an incident consist of equipment that is most readily available. That is, responders may use equipment that they have on-hand to provide immediate traffic control, and in some cases this "on-hand" equipment may be adequate for short-term incidents (e.g., Minor incidents). An initial installation might be replaced by a more elaborate system of TCDs if more time is required for processing (e.g., extrication, forensic investigation, cleanup, etc.). After arriving at an incident, response personnel will assemble their available equipment and work to establish traffic control—e.g.:

> *"We start by combining devices that are on hand, and if each vehicle only has 6 cones but it's a 30 minute incident …piece of cake. But if the incident is taking more time, then a normal traffic unit brings out full setup of TCDs, cones, barriers, barricades…etc."* [Interview 3].

Responders might expect support from other agencies but are aware that their initial response may go unaided for two hours or more—e.g.:

> *"Once we hit that 2 hour mark we expect DOT to be in place to establish work-zone like warnings and signage to guide people through an incident scene"* [Interview 1].

There are a variety of temporary TCDs that are available for TIM (e.g., static signs, variable message signs, flares, cones, barricades, responder vehicles, reflective personal safety garments that many responders wear, etc.). Through the use of temporary TCDs first responders try to capture the attention of drivers and provide them appropriate information to reduce the occurrence of vehicles intruding on the incident that originally required their response.

### *Static Signs*

Static signs are used to provide traffic control, advance warning, and to present information for detouring traffic away from an incident. The use of static signs for temporary unplanned events is low overall but more prevalent in rural areas than in urban or metro areas. In general, the use of static signs varies as a result of funding, which is needed to acquire signs and have adequate personnel available for installation. A supervisor from a TMC told us the following in regards to standard roll-up advance warning signs:

> *"We actually just helped a Fire marshal who had some extra money from a separate safety project, which was about $18,000 for 750 fire departments. The plan was to spend half on pink signs and half on pop up cones. Considering these budget constraints, the actual use of that stuff is low, some areas that have them but not a lot. We recognize how sparse their resources are…"* [Interview 6].

We researched prices and found that these signs can cost $290. To provide just one sign to each department would require more than 12 times the budget available to the Fire marshal—see: http://www.escommunications.net/Emergency_Scene_Ahead_Sign_p/fresa36pnk.htm

Financial constraints can lead to staffing shortages that can consequently impact response capabilities associated with installing and removing signs:

> *"There are just not enough people to do some of the things that they would like to do because they might only have 3-4 people doing things that 10-12 people were doing 30 years ago."* [Interview 1]

> *"I don't have time or the manpower, ever, to set up true advanced warning sign like MUTCD suggests. During the daytime I got 4 deputies covering 400 sq. miles. At night 1 deputy covering same area and his priority is not traffic control. He might put one or two flares on the road, then let the public sort of figure it out'* [Interview 8].

Rerouting traffic is an expensive TIM procedure. To reduce future costs, agencies will install permanent traffic control when possible—e.g.:

> *"As a business model we have started to put detour and re-routing signs up and leave them up. This way, it's much cheaper to get these types of signs out there."* [Interview 9].

As an additional cost saving measure, this interviewee also indicated that his agency leaves permanent routing signs uncovered and visible, which is contrary to some guidelines (e.g., MDOT general guidelines indicate signs for rerouting should be covered when not in use).

One SME told us about the cost saving potential of a certain type of sign that would also make it easier for responders to do their jobs. But his responders are unable to use the signs because the MUTCD does not contain information on their specification. Specifically, he uses what are called Triopan folding signs, and uses them mainly for training purposes. These signs are compact and have three sides, which provides for multiple messaging options with less overall bulk and less cost. In addition, the ease of installation may facilitate a responder's ability to establish traffic control. In reference to the physical design of the Triopan folding sign and its storage case:

> *"The signs pull out of a carrying sleeve and when they're opened, the sign sits on the ground as triangle, like a tripod. It's wind resistant. It can have 3 messages, so that is beneficial from a cost standpoint. By using one of these, it would enhance a responder's ability to go to work, and that's the biggest thing"* [Interview 8].

We were told that the motivation for using these signs as training tools is to stimulate discussion regarding the set-up of advanced warning. Although the stated intention was a bit difficult to interpret, it seemed the purpose was to illustrate to trainees that setting-up the typical signage is quite complex. When referencing the typical advance warning (e.g., roll-out EMERGENCY SCENE AHEAD sign, with folding aluminum stand):

> *"The problem with other signs for advance notification, it's not that we can't do it, but we don't have time because it is not easy; responders can't just go ahead and drop it. They have to unfurl it, place it on the mount, weight the mount legs if there is wind"* [Interview 8].

We were provided a description of some custom messages that were printed on the Triopan signs:

> *"I have 4 Triopan signs for training. They're 30 inches tall and on one side there is a STOP sign, on another side there is a diamond shaped red boarder with a message inside that says FIRE, on the third side there is a red triangle boarder with a message that that says ACCIDENT."* [Interview 8].

Again, we were told the reason the signs are not used for responding to real-world incidents was that the State DOT decided that they were not compliant with MUTCD:

> *"…We don't deploy them because everyone at the state level says we can't use them because they're not compliant with MUTCD. They didn't want to look outside the box"* [Interview 8].

Triopan folding signs have widespread use in European countries and were actually used for an incident in a rural area in the United States where a house-fire blocked traffic. The general messages seemed effective at providing general traffic control but the measure of effectiveness is a little too insubstantial to draw a meaningful conclusion:

> *"It seems people still gawked at the house fire, but they were attentive in their gawking"* [Interview 8].

The notion that budget constraints are a reason for the limited usage of static signs is muddied by the prominent use of expensive portable variable message signs by metro area incident responders, who operate in areas where budgets are likely greater. It seems more likely that it is a combination of the deployment issues (e.g., agreeing who installs and removes them) and costs.

### *Variable Message Signs (VMSs)*

The use of VMS in general will be addressed in this section. Permanent and portable Variable Message Signs (VMS) are used to inform drivers of incidents and traffic queuing, for general messaging, and for directing lane mergers. The type of information provided through VMS is very similar to information presented using static signs. The main differentiation is that VMS are dynamic in that messages can be changed almost instantly, and the message options for any one VMS are quite broad.

Some state DOT guidelines (e.g., ODOT [23]) indicate that VMS should be blank unless there is an event on the roadway that requires presenting messages to aid drivers in their response (e.g., slow down) or decision making (e.g., take a different route). Alternatively, a state signing engineer provided the following perspective on the use of VMS. His perspective has a slight nuance in that a message is always shown. Continuously presenting driving relevant and useful information may increase drivers' usage of VMS, thus making them more likely to read VMS incident messages:

> *"If there's an incident, state traffic operations can use overhead Changeable Message Signs (CMSs) to quickly warn and guide traffic. If our permanent boards aren't displaying an incident management message they will display minutes or miles to the next city. Our CMSs are never blank"* [Interview 4].

A SME from a rural agency indicated that the VMS in the nearest metro area is used to tell drivers which roads to expect delays on when there are traffic incidents in his region:

> *"We started to use electronic signs that light up if an incident is blocking a roadway. These signs are located about 80 miles from our small town in order to start detouring people before they get too far"* [Interview 7].

Some discussion about permanent VMSs and Lane Control Signs (LCSs) is below, and is grouped together as a result of the similarities in usage. Both types of signage may be supplemented by other traffic control equipment like portable VMS, static signs, cones and flares. The following discussion indicates both VMSs and LCSs are occasionally used in a more limited fashion and that there are instances when nothing is shown (e.g., Blank-out Signs). Interview 6 provided the following:

> *"We don't use the overhead signs for recurring congestion. However, if there is unexpected congestion and especially if it causes a high speed differential, then we will post messages like, INCIDENT AHEAD or PREPARE TO STOP. Sometimes we provide a variable speed advisory on the LCSs, and we think this has been quite helpful for slowing drivers when queues develop. For example, drivers traveling 70 mph that see a sign that says 45 mph is the advised speed might start to realize they should get ready to slow down due to slow traffic head. Also, we're investigating a dynamic queue warning system for a few corridors. These are high crash areas due to speed differentials, short queues and shock waves. Static queue warnings seem to only be helpful for people who haven't driven in that area"* [Interview 6].

There was more discussion on portable VMSs, which are designed to support a broader range of messages (e.g., the 4-dots message discussed below) compared to permanent VMSs. The desire for wider usage of portable VMS was prominent throughout the interviews. Portable VMS systems tend to be used in denser urban areas where funding sources are likely greater. Cost is likely a factor that limits wider usage of VMS (e.g., in rural areas):

> *"These arrow boards are $15,000 apiece. But they're really bright and really visible. Arrow boards are the biggest tool to allow our safety patrol to do what they do"* [Interview 6].

Although the potential to display multiple different messages is a benefit to the use of VMS, there is a tendency to use a smaller set of messages:

> *"There are 6 or so messages that are preprogrammed into the VMS systems on our trucks but the boards show chevrons 90% of the time. The chevrons are used exclusively within a traffic lane because chevrons are used only to tell people to move over. As a policy, we won't use the chevrons when attending to an incident on the shoulder. Instead we just use the 4 dots as per the MUTCD, which seems to provide some height advantage for facilitating notifying drivers farther upstream as they approach the incident on the shoulder"* [Interview 6].

Not everyone who uses portable VMSs agrees on the usefulness of the messages they display:

> *"The four dots on portable VMS, nobody in the public knows what that means. It is supposed to mean there is an incident ahead. It seems to create more of a problem than anything else. There are arguments between responders and DOT about using the four dots, we think it's not useful, but they say we have to use it because it's a rule"* [Interview 9].

Portable VMS systems that are mounted on trucks are used for situations that require more mobile traffic control:

> *"Occasionally we use a message DO NOT PASS if the responders are doing a rolling slowdown, which is a back and forth across the lanes to slow all the traffic down, or if the responder is grabbing debris or pushing a stalled vehicle out of the way. Other messages are SLOW or RAMP CLOSED"* [Interview 6].

In some cases the use of portable VMSs over static signs results from issues regarding limited access to equipment and the ability to quickly and safely install a portable VMS:

> *"…we are able to get our safety service patrols out there quick enough and with their VMS capability, which can be used to provide advance warning, the static signs become less necessary. Again, the issues with the static signs go back to who is responding and who has access to those signs. On our throughway roads, if it's maintenance people who are responding, they have access to those signs and will bring them"* [Interview 9]

## Other TCDs

### *Cones and Flares*

The use of cones for installing a traffic taper is covered in existing guidelines documents (e.g., WisDOT [29]; Delcan & GDOT [8]). The SMEs we interviewed generally agreed with the usefulness of installing a traffic taper. However, some intriguing discussion arose when the use

of flares was compared to cones. The comments below highlight some key advantages and disadvantages of using cones and flares to enhance the visibility of the incident or create a taper.

An interesting use of cones is worth mentioning here. Cones can be placed within the driving lane to make the lane width seem narrower to drivers, which slows traffic:

> *"We found out that if you move the cones 1-ft off-set from the lane line but toward traffic, traffic speed slows down considerably. This is a trick we use all the time"* [Interview 7].

This is likely an effective method for slowing traffic for rural incidents. It is unlikely to be useful for scenarios with higher traffic volumes where slowing traffic creates undesirable speed differentials that lead to vehicle crash issues.

There is a notion that since cones are small, many can be combined and then stored in a vehicle, which seemed promising for increasing their general use:

> *"We try to keep things modular. I can grab a stack of cones and throw them in the back seat"* [Interview 6].

But other SMEs said that vehicle space is mostly occupied with other equipment and there is no space for storing even the most compact cones. Additionally, a big safety-related drawback regarding cones is that they have to be retrieved, and since they are often deployed in traffic lanes, retrieving them can be unsafe:

> *"It's extremely dangerous to be outside of the safety-area recovering cones, even if you're wearing your safety vest. Personally, I've had to jump over guardrails to get cones because when they get struck by traffic they get deflected away from the scene. Alternatively, flares are more useful than cones because I don't have to recover them."* [Interview 9].

Rural agencies provided their techniques for using flares when the incident duration becomes longer. Flares can be laid out in a z-pattern where the end the flares are joined such that when one burns down it ignites another. Such practice is important in areas that operate without dedicated TIM staff:

> *"We place flares in a z-pattern on center line to act as a visual aid and this buys us 150 feet on average. Three flares in a z-pattern provides about 45 minutes to an hour of illumination. A standard flare lasts about 20 minutes if you put 3 on the ground 1 then I have 60 minutes of flare. The issue is that rural communities don't have the staffing to dedicate someone to TIM"* [Interview 8].

### *Blocking Vehicles*

This section discusses the use of vehicles to block traffic from crashing into responders or other people present at the incident. Vehicles are often used as TCDs for traffic incidents, and many guidelines documents recommend using vehicles as blockades to protect the incident scene (e.g., WisDOT [29]; Delcan & GDOT [8]). Police cruisers and fire trucks were discussed during

our interviews in the context of their use as a barrier between traffic and the incident. There are some negative aspects of using vehicles as blockades:

> *"Using a fire engine as a blockade in the place of a traffic incident management device is a fix (i.e., Band-Aid) and is not the ultimate solution. The ultimate solution is having an apparatus that allows for us to redirect drivers focus, and act as a cushion that won't kill the drive, like a Truck Mounted Attenuator (TMA). Fire uses an engine because it's there, they have it on-hand, but ultimately it's not in the best interest to use them as blockades for incidents"* [Interview 8].

The use of a TMA at traffic incidents was discussed during Interview 5 as a device that is designed for high-speed collisions. We were told that TMA has been crash tested to 62.5 miles per hour and were provided a story about a high-speed collision with a TMA that resulted in very minor injuries. Practical applications of TMA for TIM were discussed in later interviews (e.g., interviews 6 and 8) which eluded to the use of TMA as impractical due the typical response vehicles (i.e., there are no fire apparatus TMAs) and the trucks that have the appropriate weight are typically used for other purposes (e.g., dumping sand on icy roads), which means TMAs are not permanently mounted and would require installation time. The processes of swapping a sand spreader for a TMA may require additional time not typically available when responding to traffic incidents.

If a vehicle actually crashes into a fire apparatus it may need to be placed out of service, which might have an impact on the community for a long period of time. The comments from Interview 8 provide adequate perspective:

> *"When you look at the cost of a fire apparatus, it might be $500,000 to $1 million and is often purchases with private funds, where the community might contribute by doing a lot of bake sales and auctions. To raise money like that to buy an apparatus and then wreck it would be a problem. Although most insurance companies will replace a damaged engine it doesn't happen quickly, it takes 8-months"* [Interview 8].

Other responder vehicles that are used as TCDs are not used in the same way as a fire apparatus. Police cruisers are used to enhance the conspicuity of the incident, which is done in two ways. One way is by using the emergency lights typically mounted atop the vehicle, which has been shown to be effective in ushering drivers around an incident (e.g., Carrick & Washburn [(4)]). The second method is to park a cruiser at an angle that orients the reflective police decals towards on-coming traffic—e.g.:

> *"Police officers are sometimes located at the end of a traffic queue, parked at a 45 degree angle so the side of the vehicle is visible"* [Interview 3].

The functional value of this practice is unclear. The notion that the visibility or legibility of decals serves a traffic control function merits investigation. The suggestion that the visibility of police vehicle markings is beneficial, in addition to emergency lighting, implies there is some meaningfulness beyond simply enhancing general visibility of the vehicle. Other types of reflective markings are effective but are less specific. The use of reflective striping and

chevrons on the reverse side of fire response vehicles has become universal due to how such devices satisfy their visibility needs, and this occurs despite the absence of regulations:

> *"There isn't a vehicle in a fire department now that doesn't have striping, chevron backs, or the side reflective marking. Even though the NFPA 1901 doesn't say it's needed, agencies are retrospectively taking their fleet and adding the markings because they see the value"* [Interview 8].

***Non-vehicle Blockades***

This section discusses alternatives to vehicles as blocking devices. As mentioned already, the use of non-vehicle blockades was discussed by our SMEs from rural agencies (e.g., barrels and makeshift pipe and cone barricades). The lack of discussion regarding non-vehicle blockades with our non-rural SMEs gave an overall sense that rural agencies were more likely to use non-vehicle blockade devices compared to agencies that respond to incidents in centralized metro areas. Yet, there is a large degree of trial and error before rural agencies come up with workable blocking TCDs.

Rural responders' ability to block roads was enhanced when they created a device to firmly link cones together to create visible barrier. This is likely a practice only used for incidents with a long enough duration that allows for assembling TCDs. The development of this technique is described in the following:

> *"We've learned that people will try to go around or drive through cones that are just placed out there. So, we made a barricade using telescopic pole and a set of traffic cones. Picture a piece plastic pipe that telescopes out to 10 feet that is wrapped in silver and orange reflective tape. On the ends of the pole there are plastic loops large enough to wrap around the narrow taper of a cone. Use two cones and place the pole between them in order to create the barrier across. The telescopic pole works very well as a barricade"* [Interview 7].

The same discussion brought about the notion that people will overrun blocking TCDs to get to their destination—e.g.:

> *"We only close half of the road. If there's a fire down the road and people can't see it, we'll put up a sign that says ROAD CLOSED, LOCAL ONLY and leave the other side of the road open, but place a cone on the shoulder of the open side. If you close the road completely people will either drive over or move the barricade. If they bypass our partial barricade and find us at the end. Instead of getting mad at us they see why we closed it and we say, 'You chose to drive down the road, we told you it's closed.'"* [Interview 7].

Blocking TCDs are more likely to remain intact if there is some flexibility provided to drivers to overrun a TCD without removing or destroying it. Alternatively, we were told that a responder might be stationed at a blockade when an adequate number of staff is available. A responder at a blockade can inform drivers of the incident and inform other responders about drivers who bypass the blockade and drive toward the incident.

***Resources, Response Capability and Backup***

There was discussion on resources, response capability and available backup resources for when additional support is required. Some agencies cannot depend on their state DOT to respond and set up Temporary Traffic Control (TTC) in adequate time—e.g.:

> *"…for the first 2 hours of an incident, it is basically up to the public safety personnel who respond (e.g., law enforcement, fire and EMS). …often DOT resources are not available in that time frame, so the burden falls on the fire department, law enforcement, and sometimes EMS to provide and deploy the signs"* [Interview 1].

Responding agencies who often have to install a full set of TCDs have specific, equipment, vehicles and staff that they call upon—e.g.:

> *"…our incident truck has 200 cones, 5 sets of barricades, 9 brackets for advance warning signs. All it takes is a call from police dispatch, and it goes out. It's not on the road all the time, but it ends up being a cost"* [Interview 3].

This type of response is unlike the incident response capable safety patrols used in several metro areas (e.g., Atlanta, Minneapolis, Milwaukee, Seattle, etc.), which are significantly more costly to operate.

There are incidents during which even the services dedicated to TIM do not have adequate equipment, but these are typically more complex incidents that may occur at a low frequency. When speaking about the traffic control capabilities of Fire-police it was said that DOT is needed to provide adequate support for long-duration incidents:

> *"…if it gets to be a prolonged incident, an 18-wheelers spills something, DOT will take over, then Fire-police will be released, but fire will stay, and hazmat will stay."* [Interview 7].

Although Fire personnel respond to many traffic incidents providing traffic control is not yet part of their core mission:

> *"Fire stations nationwide probably respond to more roadway incidences than actual building fires these days. Still in the mission statement for Fire response, the core responsibilities are Fire abatement, extrication and caring for injured persons. The emergence of National Unified Goal (NUG) is increasing the expectation that fire will provide traffic control"* [Interview 2].

The purpose of traffic incident management may becoming less clear as the NUG progresses. The National Traffic Incident Management Coalition (NTIMC), which is a multi-disciplinary organization of public safety and transportation professionals, indicates the value and goal for TIM in the following manner:

- TIM should enhance the safety of on-scene responders and of motorists passing or approaching a roadway incident.
- TIM should reduce incident delay and costs to the traveling public and commercial carriers.

SMEs indicated that ensuring the safety of responders and others at the incident does not correspond well with the notion of reducing the impact of the incident on traffic flow (e.g., incident delay and costs):

> *"…It's counterproductive if the purpose of TIM is to make the road safe for First responders and not to impinge on drivers getting from point A to point B. If we shut down a road, it's a million dollars a minute and we understand that. But, our job is to protect responders and injured; we need to protect them. In order to minimize impact on road traffic we would need to develop a scoop and dump method to scoop up the incident and first responders to get them out of the way. The goals of keeping responders safe and taking care of people are at odds with being able to maintain traffic flow."*[Interview 8].

## SME INTERVIEW CONCLUSIONS

A key theme across the discussions with SMEs was that the messages that are currently in use seem to be adequate and are used across multiple situations in a general manner. There is some supporting evidence provided by the SMEs regarding the need for general messaging. There is some understanding that consistency in messaging across all events that require traffic control enhances driver understanding. Yet, given that there is a wide variety of traffic incidents, responders still need the flexibility to augment their messaging, and there are procedures in place to do this, but these may rarely be exercised. Further evidence that general messaging is important comes from the use of VMSs. Although the messaging options of portable VMSs are greater, there is a strong tendency for responders to almost exclusively use a small set of messages (e.g., 1 of 6 preprogramed options). This finding implies that there is a tacit practical limit to the number of messages for responding to common incidents.

Procedures for setting up traffic incident management and assigning agency responsibility are issues that still need to be determined; several SMEs implied that modifying libraries of existing messages is of lower importance. A major issue that was mentioned by several SMEs and evident in our review of current practice indicates that low funding can prevent agencies from acquiring the proper TCDs and employing an adequate amount of staff to provide traffic control for a traffic incident. To further complicate understanding the budget issues, there are areas that have safety service patrols with portable VMS capability that do not use the cheaper static signs. The portable VMS likely facilitates installation and removal of TTC to a degree that is more preferable compared to static TTC.

TCDs (e.g., cones, static signs, etc.) that are placed within the driving lane can be dangerous to recover once they are no longer needed. This could be a motivating factor for low usage of TCDs for incidents that trumps the budget constraints, but another constraint may be space. Space is usually not available for storing TCDs in responder vehicles (e.g., a police cruiser or and fire apparatus). Areas with sufficient funding can afford to outfit secondary response

vehicles with a full set of TCDs for responding to incidents, but these vehicles are more often called to an incident by other first responder agencies, they are not the first to arrive. It seems sensible that VMS mounted on the top of a vehicle would be more likely to be implemented for a traffic incident than cones and static signs. Such vehicles are in high use in some metropolitan areas that can fund them, and they serve as roving response units responding to minor traffic incidents (e.g., breakdowns, or drivers with no fuel). Additionally, there are pilot programs testing the use of a VMS mounted on the top of a fire apparatus. This is pertinent considering that TIM is not yet part of the mission statement for Fire response. Historically, when fire abatement, extrication and first-aid are not needed Fire responders were relieved from the incident. It is not clear if the relatively new traffic control responsibilities will require Fire agencies to remain on-scene longer. Police are typically responsible for traffic control for traffic incidents. Yet, VMS on police cruisers has yet to be implemented, as far as we know. Increasing VMS capabilities on vehicles that are first to arrive at major incidents and carry primary responsibility for traffic control may be a promising safety enhancing direction.

Although SMEs understand that the options available to responders are limited there was general agreement that the use of a fire apparatus as a blockade is inappropriate and should not be considered a sustainable practice. Blockades are a useful tool for traffic control. Agencies often have to improvise or fabricate blockade devices that work given their constraints (e.g., limited vehicle space and low funds). For rural incidents that restrict roadway access, non-vehicle blockade traffic control measures have evolved from simple cone layouts to more complex blockade systems (e.g., the telescopic cone connector in Interview 7), and strategies for installation (e.g., a partial road blockade).

Agencies that respond to traffic incidents require flexibility in the methods they use when responding to incidents. The majority of incidents are non-major, lasting for brief periods of time but most of the MUTCD is written for responding to major incidents. This can cause a problem for agencies building up their response capabilities. Standards, regulation and guidance from governing bodies (e.g., state level TMCs abiding strictly by MUTCD) may prevent the application of TCDs that have been shown to enhance responders' ability to setup advance warning (e.g., the use of Triopan folding signs). The guidance in the MUTCD may need to differentiate between various levels of response in a way that is more in line with responder capability.

# CHAPTER 4. FOCUS GROUPS

The methods we used to carryout focus group interviews, the results and key conclusions are discussed in this chapter. We used the information from the Literature and practice review and the SME interviews to generate key scenarios and topics for focus group interviews. Focus group interviews were conducted with first responders and with drivers from the general public. These were brainstorming sessions in which participants developed sign messages applicable to the relevant scenarios. Participants were encouraged to think of verbal and symbolic messages that could be used for multiple incidents.

## FOCUS GROUP METHOD

Focus groups were carried out using a low-fidelity table-top method. Poster-sized aerial images of roadways and vehicle miniatures were used simulate traffic incidents. A response book, post-it notes, pens, and markings were used to collect responses. Focus group sessions were video recorded and short-hand notes were taken. Battelle's IRB reviewed and approved our approach (Appendix D) which is discussed as follows: 1) *Participants*, 2) *Materials*, 3) *Procedures* and 4) *Analysis* of the focus group information.

### Focus Group Participants

Incident responders and drivers from the general public participated in separate focus groups. Participants were from areas near Seattle, WA and Tacoma, WA. Before starting the focus groups, each participant read over the briefing form in Appendix E and was allowed to ask questions. Participants provided verbal consent to participate in the focus group.

#### *Incident Responders (IRs)*

A total of 8 IRs participated in two focus group sessions (6 male, 2 female). The Washington Traffic Incident Management Coalition (WaTIMCo) and WSDOT recruited participants for the first responder focus groups. IRs were not paid by the research team for their time. See Table 3 for details on the IR group. Both IR focus group sessions were carried out on the same day.

**Table 3. Demographics of the Incident Responder (IR) focus groups.**

| Group | Age | Gender | Current Occupation | Years in Current Occupation |
|---|---|---|---|---|
| 1 | 47 | M | Fire Department/Battalion Chief | 30 |
| 1 | 48 | M | Incident Response Lead Technician | 11 |
| 1 | 57 | M | WSDOT Traffic Safety Systems Operator 3 | 10 |
| 1 | 44 | M | Washington State Patrol Sergeant | 21 |
| 1 | N/A | M | Joint Base Lewis-McChord Fire Department* | N/A |
| 2 | 45 | F | Traffic Safety Systems Operator | 6 |
| 2 | 40 | M | Washington State Patrol Sergeant | 15 |
| 2 | 55 | F | Incident Response Maintenance Lead Technician | 21 |

*Note:** Did not provide age or years in occupation

### *General Public (GP)*

A total of 14 drivers from the GP served as participants (7 male, 7 female). Participants from the GP were recruited using Craigslist.org. The recruitment ad is shown in Appendix F. GP participants received $75 for their participation. See Table 4 for details on the drivers from the GP. There were three GP focus groups carried out on three separate days.

**Table 4. Demographics for the drivers from the General Public (GP) focus groups.**

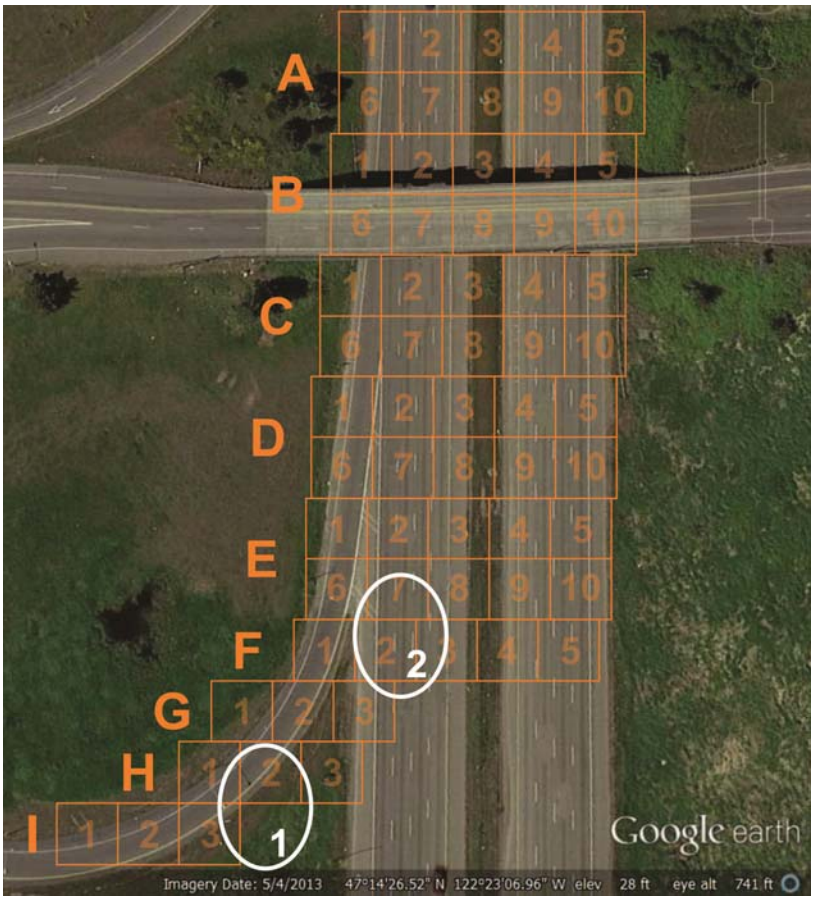
| Group | Age | Gender | Current Occupation | Years in Current Occupation |
|---|---|---|---|---|
| 1 | 63 | M | Energy Auditor/Sales | 5 |
| 1 | 43 | M | Self-Employed (Product Delivery) | 6 |
| 1 | 58 | F | Retired Construction Worker | 24 |
| 1 | 26 | M | Real Estate Appraiser | 1 |
| 2 | 58 | M | Semi-Retired Broadcast Engineer | 36 |
| 2 | 23 | F | Student | 4 |
| 2 | 58 | F | Editor | 15 |
| 2 | 29 | F | Server | 11 |
| 3 | 53 | M | Apartment Manager | 8 |
| 3 | 24 | M | Student/Retail Sales Associate | 5 |
| 3 | 77 | F | Artist (Painter) | 30 |
| 3 | 59 | F | Home Health | 10 |
| 3 | 32 | M | Construction | 2 |
| 3 | 41 | F | Homemaker | 3 |

### Focus Group Materials

The focus groups were asked to provide message ideas, to indicate where in the scenarios the message should be located, and to define the meaning of the message. A moderator conducted the focus groups. The materials that were used to carry out the focus group are described below:

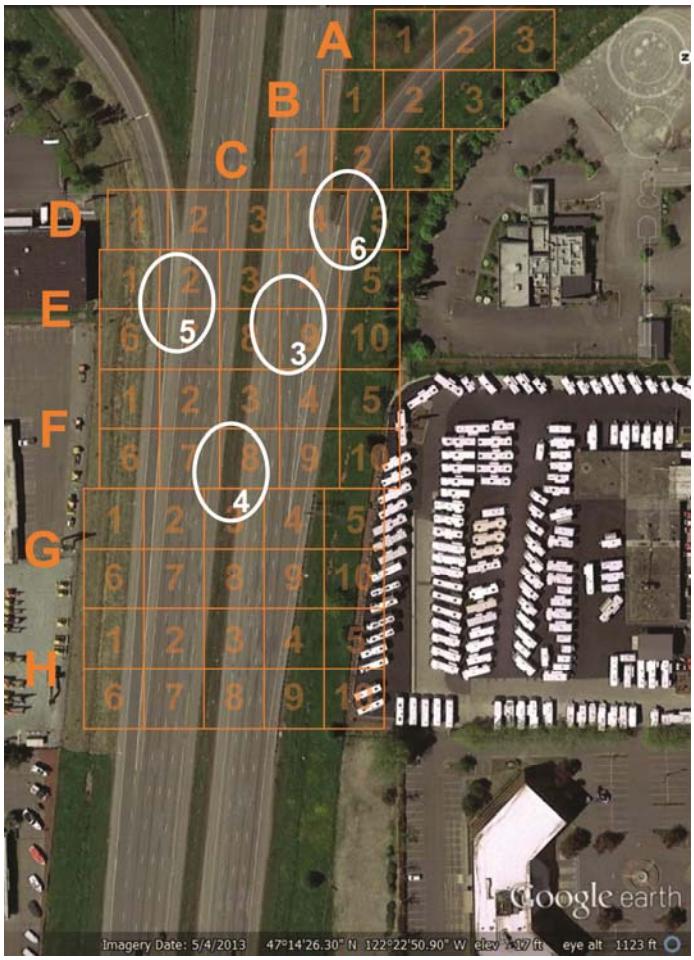
- *Moderator guide*: the moderator guide explained the briefing form, the ground rules and the objectives of the focus group. It also contained lists of questions that the moderator could use if needed during the focus group. The moderator guide is in Appendix G.
- *Poster-size aerial images of roadways*: The images shown in Figure 5, Figure 6, and Figure 7 were printed as 3’ by 4’ laminated posters. The images were obtained using Google Earth in satellite view, and there is an orange grid that is overlaid on the images (discussed in the procedures).
- *Vehicle models*: A set of Micromachines® that contained emergency response vehicles, passenger vehicles and heavy trucks was used to create incident scenarios.
- *Response books*: The response book contained the following sections: a short demographic survey; an introduction to the focus group method with example messages and instructions; information on how to use the book for writing down responses; a reference map was provided to give additional context when needed; descriptions and

images for 8 scenarios. The scenarios were shown on single pages, and accompanied by space for participants to write their responses. See Appendix H.



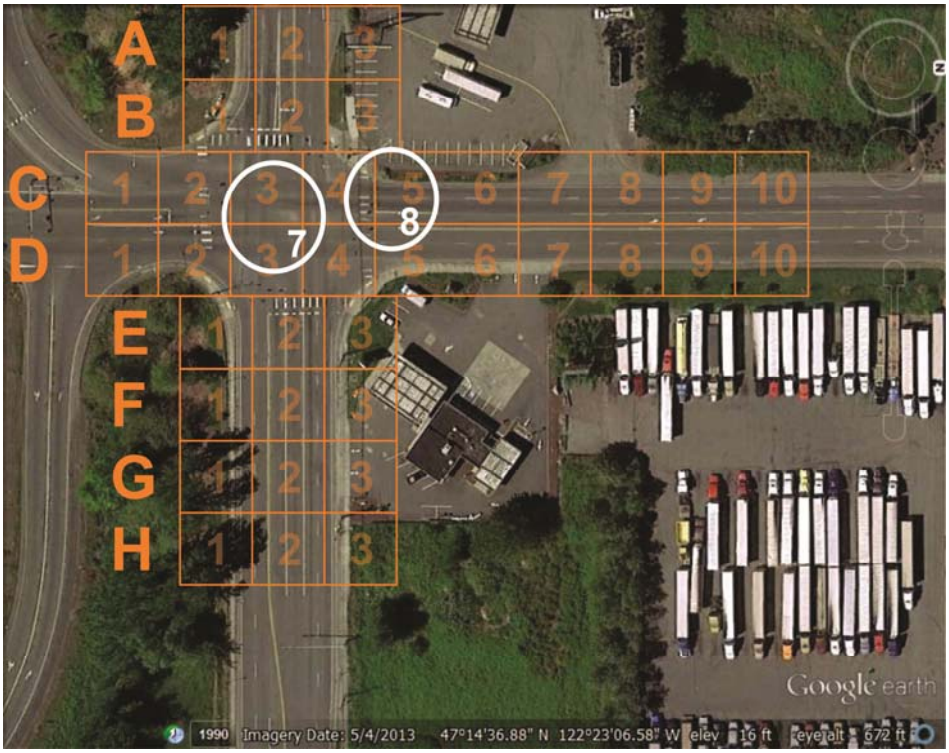

Original image: ©2013 Google®; map annotations provided by Battelle (see "Acknowledgements")

**Figure 5. Scenarios 1 & 2** [14]




Original image: ©2013 Google®; map annotations provided by Battelle (see "Acknowledgements")

**Figure 6. Scenarios 3 to 6** [15]




Original image: ©2013 Google®; map annotations provided by Battelle (see "Acknowledgements")

**Figure 7. Scenarios 7 & 8 [16]**

## Procedures

The focus groups were conducted April 21st to the 28th, 2014. Each session was approximately 90 minutes. The same person acted as the moderator for all sessions (Graving, J. S.) and short-hand notes were taken during each interview by a trained observer staff (Bacon, L. P.). Video and audio of each session was recorded. The videos were used for recording participant responses and comments. The videos were deleted at the completion of this project (September, 2014).

The moderator guide was used to introduce the ground rules, review the topic for the focus group and inform participants of the options for providing responses (i.e., writing in the book, and contributing to discussions). The introduction page on the response book showed examples of message options as well as message presentation and installation techniques. The introduction page served to explain the multitude of options for presenting messages to drivers. While reviewing the examples with participants, we specifically stated that the purpose of the focus group was to brainstorm message ideas, and since there are multiple ways to present messages, they should assume there are no specific constraints on how messages are presented. The first 10 minutes of each session was allotted to reviewing this introductory material.

After the introduction, the first scenario was simultaneously explained and set up. After the scenario was set-up, participants were given a few minutes to assess the incident and write

down their ideas for sign messages. When it appeared to the moderator that most of the participants had generated at least one idea, the floor was opened for discussion and participants were asked to describe their messages, to indicate where they would place the messages and to describe the rationale behind their message ideas. Participants were encouraged to edit their responses or add additional notes if as needed during the discussion segment. This procedure was used for all eight of the scenarios.

There were eight incident scenarios (see Table 5). Approximately 10 minutes was spent for each scenario for setup, sign message idea generation, and discussion. For the first scenario only, to serve as an example of how to respond, the moderator started the discussion by explaining a set of messages, placing post-it note versions on the scenario at the proper locations, and describing the purpose of each message.

**Table 5. The eight scenarios used in the focus groups.**

| Order | Scenario Description |
|---|---|
| 1 | Partially blocked sharp curve freeway off-ramp during the peak hours of the day<br>• A grain truck tipped over and spun while exiting and is on its side.<br>• A large amount of grain is on the exit ramp.<br>• The grain is blocking the exit lane but the inner shoulder is clear. The shoulder is wide enough for people to drive on.<br>• Traffic volume is high and will back-up quickly. |
| 2 | There is a multi-car collision blocking most lanes<br>• A crash between multiple vehicles blocks the right shoulder and all driving lanes.<br>• The left shoulder remains unblocked.<br>• Traffic is heavy. |
| 3 | Middle lane collision during the peak hours of the day<br>• A severe two-car crash occurred in the middle lane of a three lane highway.<br>• The shoulders and the outside lanes are clear.<br>• Traffic volume is high and will back-up quickly. |
| 4 | Middle lane collision during the peak hours of the day<br>• An immobilized jack-knifed truck is located in the median.<br>• Middle shoulder and both adjacent lanes are blocked.<br>• All other lanes are unblocked.<br>• Traffic volume is high and will back-up quickly. |
| 5 | Shoulder collision between entering vehicle and mainline traffic<br>• A rear-end collision between a small car and a heavy-truck occurred when a driver merged too early into the mainline traffic when entering the highway.<br>• The shoulder and first adjacent lane are fully blocked.<br>• The entrance ramp is partially blocked but the far hard shoulder clear. |

| Order | Scenario Description |
|---|---|
| 6 | Crash on the exit ramp due to a last minute exit during atypically high traffic<br>• There was a severe multi-vehicle crash in the exit ramp due to a driver's decision to exit at the last second.<br>• In addition, the Mazda plant is having a surprise car show that is now drawing a huge crowd from Seattle. The crash has already caused a traffic back-up.<br>• The exit ramp is completely blocked but all mainline lanes are clear. |
| 7 | Middle intersection collision during the peak hours of the day<br>• A two-vehicle collision at a signalized 4-way intersection is blocking through traffic.<br>• Right-turn lanes are clear.<br>• Traffic volume is high and will back-up quickly. |
| 8 | Pavement failure at a 4-way intersection<br>• A pipe burst under the Port of Tacoma road and caused the pavement to collapse.<br>• Underground plumbing for a nearby business is suspected to have caused it.<br>• Southbound lanes are blocked, including through-lanes and, right and left turn lanes. |

**Analysis**

Messages and relevant discussion points were extracted from short-hand notes and audio/video recordings. Relevant segments of lengthy discussion points were reduced down to their useful content (i.e., the gist of what was being said ended up in the results). All message ideas were treated identically. In other words, message ideas from all participants were included in the analyses independent of whether the idea was a result of a group discussion or a participant comment, or taken from the response book.

Additional analyses were carried out on the messages, which were qualified based on their information content by using the concept of *information units* (IUs)**.** An IU refers to the elements of a message that a driver may recall and use as a basis for decision making, and is typically an answer to a question a driver may have (e.g., An IU that says CRASH would answer "What is the problem on the roadway ahead?"). An information unit is simple and brief, and typically 1 to 3 words. Multiple information units can appear within a single message (e.g., CRASH; LANE BLOCKED; USE ALT. ROUTE).

For the purposes of this task, we used guidance for IUs for roadway messages for changeable signs (e.g., Dudek [9]) and extended it to the other relevant mediums for presenting messages to drivers (e.g., static road signs). We used the IUs described in Dudek [9] to codify the informational quality of the messages that were generated by the focus groups. To accomplish this, we generated a checklist that contained the messages and IUs, then 1) tabulated the frequency that each information unit was used across all message, 2) summed the quantity of messages that consisted of one or more IU; then 3) listed the most common IUs.The information units are listed below:

**IU 1**. Contains a ***P**roblem Descriptor* that indicates what happened (e.g., CRASH)

**IU 2**. Contains an ***E**ffect Descriptor* that indicates the effect the problem has on traffic (e.g., HEAVY CONGESTION, LANE BLOCKED).

**IU 3**. Contains an ***Att**ention Descriptor* that indicates the audience the message is addressing (e.g., MOTORCYCLES, I5 TRAFFIC).

**IU 4**. Contains an ***Act**ion Descriptor* that indicates what is expected of drivers or what they should do (e.g., USE ALT. ROUTE, SLOW).

**IU 5**. Contains a ***L**ocation Descriptor* that indicates the location of either the incident or the effect the incident has on traffic (e.g., a roadway name, ON HWY 5). Note – we did not consider the term "Ahead" as a descriptor of location. Guidelines suggest that this term is redundant with other descriptors of location as it is implied by the problem descriptor [(9)].

The three methods of qualifying the messages are shown in the results and discussion section for the overall message set, and for the IR groups and the GP groups. The three methods provide perspective on the type of information the focus groups thought was relevant, and how much information they thought could be used within a message.

## RESULTS AND DISCUSSION

Summary statistics and relevant findings from the focus groups are discussed below. A table that contains all the messages generated by focus group participants is located in Appendix I. The Results and Discussion section first introduces summary statistics for the messages over all the focus groups, then summary statistics and pertinent discussion points are discussed for the IR groups, followed by the GP Groups.

### Summary Statistics for the Overall Message Set

Across all focus groups and scenarios, participants generated 350 messages that consisted of 550 IU phrases. Table 6 shows how the different groups contributed to the summed total of messages. There were differences across the focus groups in the number of scenarios that were presented, and the quantity of messages that were generated. These differences resulted from the method participants chose to contribute to the focus group (e.g., discussion or writing their responses in their Response Book), if they were in the IR or GP group, and the number of people in the group.

The primary mode of response for the IR groups was through discussion, which was substantial due to its concentration on relevant topics. The primary mode of response for the GP group was through note-taking, which was less focused than the IR group but high in volume. The first GP group provided a fair quantity of messages through their light discussion, but their notes were less useful compared to the other GP groups.

**Table 6. Scenarios and messages across the focus groups.**

| Group | n | Scenarios Completed | Modes and Quantity of Responses | Engagement Rating | Messages Generated |
|---|---|---|---|---|---|
| IR_1 | 5 | 1-4; 7 & 8 | Substantial discussion; Light notes | High | 30 |
| IR_2 | 3 | 1-8 (All) | Substantial discussion; Minimal notes | High | 25 |
| GP_1 | 4 | 1-8 (All) | Light discussion; Minimal notes | Low | 30 |
| GP_2 | 4 | 1-8 (All) | Light discussion; Appropriate notes | Marginal | 90 |
| GP_3 | 6 | 1-8 (All) | Appropriate discussion; Appropriate notes | High | 175 |

Table 7 shows a use-frequency for each IU category across all messages. Action phrases were the most common type of IU (242 phrases), followed by Effect and Problem phrases (123 & 122 phrases). The least common phrases were for Attention and Location information (20 & 43 phrases). The bias towards Action phrases lines up with the most common repeated discussion point across all focus groups, which was that it is important to tell drivers what it is they need to do.

**Table 7. Use-frequency per IU across all messages.**

| IU | Problem | Effect | Attention | Action | Location | Total |
|---|---|---|---|---|---|---|
| Count | 122 | 123 | 20 | 242 | 43 | 550 |

Although most of the messages that participants generated consisted of only one IU, there were many messages that contained two and three IUs. Table 8 shows how many messages contained one or more IUs. Most of the messages consisted of one IU (195 messages), followed by 2 IUs (110 messages), and 3 IUs, (45 messages). There were no messages with more than 3 IUs.

**Table 8. Frequency of messages with one or more IUs.**

| Number of IUs | Number of Messages |
|---|---|
| 1 IU | 195 |
| 2 IUs | 110 |
| 3 IUs | 45 |
| 4 IUs | 0 |
| 5 IUs | 0 |
| Total | 550 |

Approximately 200 of the 550 informational phrases used across all messages were unique (i.e., not repeated by other participants). The majority of informational phrases were repeated multiple times across focus groups. The top ten most common phrases across all focus groups are listed in Table 9.

**Table 9. Top 10 most common IU phrases.**

| IU Phrase | IU Category | Count |
|---|---|---|
| ACCIDENT AHEAD | Problem | 25 |
| INCIDENT AHEAD* | Problem | 17 |
| SLOW* | Action | 16 |
| MERGE LEFT | Action | 14 |
| MERGE RIGHT | Action | 13 |
| RAMP CLOSED* | Effect | 11 |
| EXIT CLOSED | Effect | 10 |
| CRASH AHEAD | Problem | 9 |
| USE ALT ROUTE | Action | 8 |
| ALL LANES BLOCKED | Effect | 7 |

*Note*: *These terms were used in the instructional section of the response book.

## IR Summary Statistics and Relevant Discussion Points

### *Summary Statistics*

The IR groups generated 55 messages that consisted of 97 IU phrases. Table 10 shows the total count of information units included in the messages from the IR groups. Action phrases were the most common type of information unit (32 phrases), followed by Effect and Problem phrases (26 & 25 phrases). The least common phrases were for Attention and Location information (3 & 11 phrases).

**Table 10. Frequency of use per IU across messages for the IR groups.**

| IU | Problem | Effect | Attention | Action | Location | Total |
|---|---|---|---|---|---|---|
| Count | 25 | 26 | 3 | 32 | 11 | 97 |

Table 11 shows the quantity of messages from the IR groups that contained 1 or more information units. Most of the messages consisted of 1 IU (27 messages), followed by 2 IUs (14 messages), and 3 IUs, (14 messages).

**Table 11. Frequency of messages with one or more IUs for the IR groups.**

| Number of IUs | Number of Messages |
|---|---|
| 1 IU | 27 |
| 2 IUs | 14 |
| 3 IUs | 14 |
| 4 IUs | 0 |
| 5 IUs | 0 |
| Total | 55 |

There were a fair number of unique messages within the IR focus groups. Approximately 60 of the 97 informational phrases used in messages were unique. Less than half of messages were repeated within the IR focus groups. The top most common phrases across the IR focus groups

are listed in Table 12. None of the top repeated messages used by the IR groups were in the introductory material in the response book.

**Table 12. Top repeated IU phrases from the IR groups.**

| IU Phrase | IU Category | Count |
|---|---|---|
| CRASH AHEAD | Problem | 7 |
| COLLISION AHEAD | Problem | 5 |
| COLLISION | Problem | 4 |
| ALL LANES BLOCKED | Effect | 4 |
| PORT OF TACOMA ROAD | Location | 3 |
| LEFT LANE BLOCKED | Effect | 2 |
| RIGHT TURN ONLY | Action | 2 |
| USE ALT. ROUTE | Action | 2 |

***Relevant Discussion Points from the IR groups***

The IR focus groups provided discussion that was very thorough and covered many topics, including three that are discussed in more detail below:

- *General effectiveness of messaging;*
- *Complex issues that do not have clear messaging solutions;*
- *Rationale behind the use of a select number of messages.*

**General Effectiveness of Messaging:**

Many incident messages used in the real-world appear to stem from intuition, then observing how they affect traffic. Some IR agencies may be better suited to observe the effectiveness of their messages than others. For instance, Traffic Management Center (TMC) operators have a better perspective than police and fire personnel.

Police and fire personnel are typically at the location of the incident, which is downstream of all incident messaging. Therefore, police and fire personnel may not actually see the messaging or the effect the messaging has on traffic. This is especially the case when the messages are installed by specialized IR technicians or put on a permanent Variable Message Sign (VMS) by a TMC operator.

TMC operators have a vantage point that allows for informally assessing the effectiveness of messages. For instance, TMC operators with access to traffic cameras can subjectively monitor how their messaging impacts traffic. In some cases, they may change what is shown on a VMS if they do not see the result they expect.

IR technicians are often able to assess the effectiveness of messages. They are often responsible for selecting the messages and they can observe the effect since the messages appear on a portable VMS (PVMS) mounted on their trucks. An IR technician told a story of a secondary incident that caused him to change the types of messages he used. A driver blamed the message on his PVMS for causing the driver to rear-end a forward vehicle. The driver stated that reading

the message contributed to looking away from forward traffic, resulting in the crash. The incident caused the IR technician to use symbolic messaging as often as possible to reduce how long drivers look at the PVMS, e.g.:

> *"The Flashing four corners keeps drivers from spending too much time looking at the PVMS on incident response trucks."*

**Complex issues that do not have clear messaging solutions:**

There are some concepts that IR personnel encounter that do not cleanly translate to driver messaging. For instance, secondary incidents caused by "rubberneckers", "gawkers" and "lookey-loos" are a major issue, e.g.:

> *"The scene itself isn't too big of a problem. People will generally figure out what we're trying to get them to do once everything is in place. It's what people do after that. If we could come up with a message to stop people from rubbernecking, that may reduce secondary incidents. Everybody turns and looks at the scene; they'll even turn completely around to look at it."*

Another difficult concept to translate into a simple message is when there are multiple options for rerouting or diverting traffic around an incident. It was noted that it can be difficult to get drivers to follow cone or flare tapers that provide more than one option for direction of travel, e.g.:

> *"… even if they have to drive over a fire hose, between fire trucks, or through cones and flares people will drive where they want to go, that is unless you force them to use an alternate route. In other words, when drivers are given options, they are more likely to take an option that will cause them major delays as long as that option doesn't require them to reroute. This is perhaps is more likely for drivers who are not familiar with the area. Drivers that formulate their own detour are preferable to us."*

An officer described a vertex taper that was used at a traffic incident that consisted of flares placed on the roadway to direct drivers to take either the shoulder to continue straight or to an exit to reroute. The vertex was rather long, and when left unattended, drivers overran the cones and flairs. A key problem occurred when drivers who decided to reroute using the exit saw other drivers using the shoulder. These drivers then merged over the cones and flares to get to the shoulder, perhaps to continue on their original route. The majority of responders agreed that limiting driver choice in where they can actually drive is a useful tactic, which can create long queues.

The need to inform drivers of traffic queues is important but there are some restrictions on the types of messages that can be used on VMSs that are permissible on PVMS, e.g.:

> *"The message USE CAUTION does not reduce driver speed. We cannot use SLOW DOWN on the overhead VMS but we can on the response truck PVMS. The thought is that if someone sees SLOW, then slows down and gets rear-ended, then there are litigious issues. There needs to be a stronger word that indicates the risk*

*to drivers that if they do not slow down they will crash. Drivers are being told about incidents that are 2 miles ahead but they actually have to stop much sooner."*

Many of the scenarios that were presented to the focus groups required traffic to merge to an adjacent area within the roadway but away from the incident. IR technicians carry static transition signs (e.g., W4-2) in their response vehicles and use them to guide traffic around an incident. An IR participant mentioned that a shift arrow for reverse curves (i.e., S-curves) would be more clear to drivers in regards to temporarily shifting traffic to an adjacent area of the roadway (e.g., the hard shoulder) when the travel lane is not explicitly closed, e.g.:

*"…a shift arrow would work better. It tells drivers to move over but not necessarily out of the lane they are in. We do not carry shift arrows. We only carry transition signs"*

Figure 8 and Figure 9 show the transition sign carried by IR technicians and the shift arrow. If the shift arrow was to be used for temporary traffic control for a traffic incident it would likely have to appear with a florescent pink background as per MUTCD chapter 6I.

**Figure 8. W4-2 Transition Sign [13]**

**Figure 9. W1-4 Reverse Curve[13]**
Note: *There are no known guidelines that state the shift arrow be used with a florescent pink background.

**Rationale behind the use of a select number of messages:**

Participants in the IR groups were able to offer some rationale for the use of a few messages.

- The IR group indicated that the message EXPECT DELAYS was taken out of use in their region and stated that other messages like COLLISION AHEAD accomplish more by indicating the problem and implying a traffic delay. This practice matches how Dudek [9] describes redundancy.

- Some words allow for better visibility of the VMS. The visibility of a VMS can be greater for smaller words like CRASH. This is because there are fewer letters, which can

then be made larger, and it is the size of bright letters that enhances visibility. Messages like COLLISION require smaller letters so less of the VMS is lit.

## GP Summary Statistics and Relevant Discussion Points

### *Summary Statistics*

The GP groups generated 295 messages that consisted of 453 IU phrases. Table 13 shows the total count of information units included in messages from the GP groups. Action phrases were the most common type of information unit (210 phrases), followed by Effect and Problem phrases (97 phrases each). The least common phrases were for Location and Attention information (32 and 17 phrases).

**Table 13. Frequency of use per IU across all messages for the GP groups.**

| UI | Problem | Effect | Attention | Action | Location | Total |
|---|---|---|---|---|---|---|
| Count | 97 | 97 | 17 | 210 | 32 | *453* |

Table 14 shows the quantity of messages from the GP groups that contained 1 or more information units. Most of the messages consisted of 1 IU (168 messages), followed by 2 IUs (96 messages), and 3 IUs, (31 messages).

**Table 14. Frequency of messages with one or more IUs for the GP groups.**

| Number of IUs | Number of Messages |
|---|---|
| 1 IU | 168 |
| 2 IUs | 96 |
| 3 IUs | 31 |
| 4 IUs | 0 |
| 5 IUs | 0 |
| *Total* | *295* |

There were less unique informational phrases within the GP focus groups. Approximately 150 of the 453 informational phrases used in messages were unique (i.e., not repeated by other GP participants). More than half of messages were repeated multiple times across GP focus groups. The top ten most common phrases across the GP focus groups are listed in Table 12.

**Table 15. Top repeated UI phrases from the GP groups.**

| IU Phrase | IU Category | Count |
|---|---|---|
| ACCIDENT AHEAD | Problem | 25 |
| INCIDENT AHEAD* | Problem | 16 |
| SLOW* | Action | 16 |
| MERGE RIGHT | Action | 13 |
| MERGE LEFT | Action | 13 |
| EMERGENCY SCENE AHEAD* | Problem | 10 |
| BE PREPARED TO STOP* | Action | 10 |
| RAMP CLOSED* | Effect | 10 |
| EXIT CLOSED | Effect | 10 |
| EXIT NOW | Action | 8 |

*Note:* *These terms were used in the instructional section of the response book.

***Relevant Discussion Points from the GP Groups***

The discussion during the GP groups covered the topics below:

- *Need for messages that provide guidance;*
- *Options for general terms;*
- *Need to divert traffic far upstream of the incident;*
- *Other technology solutions* like using media and internet to notify the general public.

**Need for messages that provide guidance:**

The high quantity of action IUs is indicative of the GP group's stance on using messages that tell drivers how they should be driving when roadway incidents occur. The following discussion point succinctly describes the general view of the GP groups:

> *"You don't need to tell drivers about the incident, really. Just tell them exactly what they need to do. A message could just say STAY RIGHT. Messages should use action words that are instructive."*

GP focus groups also described symbols that could provide action information, but also mentioned how the placement of symbolic messaging could provide information on which lanes are closed. For instance, this comment suggested placing merge arrows within a lane to indicate that the lane is closed and a merge is required:

> *"Arrows that can switch from any direction would work, and you could put it in the lane, which would show that the lane is closed."*

**Opinions for general terms:**

As shown by their minimal usage of problem IUs, there was not a strong push for information on the incident. However, the GP Focus groups stated that general messaging about an incident

may become beneficial over time if the messages are standard and have common use. A few comments on general messages are shown below.

One participant stated that general 'alarming words' could increase alertness, e.g.:

> *"To increase driver alertness, alarming words might be useful. I think EMERGENCY would work."*

Several participants stated that drivers may begin to associate common or standard messages with the quality of traffic control that will likely be available for roadway incidents, which is expected to be less thorough compared to planned incidents like road construction, e.g.:

> *"EMERGENCY SCENE AHEAD might work to help to alert people and help them realize they should expect a police car, or fire truck or something else tending to it."* – Emergency vehicles are often used as traffic control devices.

> *"Let drivers know that it's an incident by using EMERGENCY INCIDENT AHEAD; that message allows them to think that there might be less signage compared to a planned roadway event like construction."*

The GP Group expressed some awareness that it may require standardization or common usage before general messaging becomes useful, e.g.:

> *"In the future, once incident signs are established and used consistently people will start to realize which message of all the messages they're seeing relate to a traffic incident"*

The GP Group agreed that not all general messages are useful, – e.g.:

> *"BE PREPARED TO STOP and EXPECT DELAYS are not a useful message. They should say USE ALTERNATIVE ROUTE or something that isn't so obvious."*

**Need to divert traffic far upstream of the incident:**

There were a several comments about diverting traffic that is away from the incident to reduce congestion at the incident scene, e.g.:

> *"For highway incidents, if there are fewer cars coming toward the scene it will probably make it easier for the people who have to clear it. So, we should notify drivers as far away from the scene as possible."*

> *"We should mostly focus on notifying the approaching traffic so they can take a detour. This would help to keep them from causing greater problems within the incident itself. For the drivers closer to the scene, just tell them what they need to do directionally."*

*"The sign could say EXIT NOW, SAVE YOURSELF TWO HOURS, or ENTER AT YOUR OWN RISK. This would provide some value to getting off the road and maybe reduce congestion where the incident is located."*

The notion of diverting traffic also transferred to incidents that occurred on the two-way signalized intersection incidents, e.g.:

*"For intersection incidents, if there is an intersection upstream of the lanes that are blocked off, that's where the lane closure should start. First you want to reduce or eliminate traffic on the road where the incident is located. Then open lanes up when you have more understanding of what's happening and how to guide traffic."*

*"Blocking off traffic from using the roadway frees-up incident responders who may not otherwise have to be there. Say, for the sink-hole incident, if fire was there only to block the sinkhole, they could leave after traffic is cleared if all the approaching lanes where shut down at the previous intersection."* – This comment is in reference to scenario 8.

**Other Technology Solutions:**

There was some discussion on drivers receiving notifications on roadway incidents via the radio and internet. The GP group stated that the limitations to general signing (e.g., limited staff and equipment) that affect how much information is typically provided to drivers could be overcome using current technology.

One participant mentioned that messages through radio could provide more descriptions, e.g.:

*"The radio stations that receive input from the traffic incident management center may provide more useful detail than any sign can offer. It may be useful to remind drivers to tune to those stations. Knowing more about what is happening might make you less likely to get distracted with trying to determine what to do."*

There was a rather lengthy discussion about using computers and smartphones. When one participant mentioned receiving traffic incident notices on a smartphone application, there was a second participant who found that idea useful, e.g.:

*"Receiving notifications on roadway incidents is a great reason to have a computer in the car."*

## FOCUS GROUP CONCLUSIONS

The results of the focus group show a preference for brief messages for guidance on diverting away from the incident. This preference was prominent across all focus groups. The conclusions for the IR and GP focus groups are discussed below.

The findings from this focus group should be considered non-representative, and non-generalizable. Focus groups are not scientific and merely provide casual opinions and

anecdotes. Any and all claims provided by focus group participants require additional investigation.

### IR Groups Summary

The summary statistics show that the IR groups thought that driver messages should be simple as most of their messages contained one IU. They also thought that messages should primarily provide information on the actions drivers should take to get around the incident, although information on the incident (i.e., problem) and its effect on traffic were also used fairly extensively. The discussion points from the IR group provide some perspective on their tendency to state that drivers need information on the actions they should take to avoid the incident. In addition, there are insights on their measures of effectiveness, complex issues without obvious message solutions, and some examples of messages that were changed. These are briefly reviewed below:

- Some IR agencies are able to informally assess the effectiveness of the messages that are deployed. Their measures of effectiveness are subjective but do lead to identifying useful messages (e.g., CRASH), or to excluding of less useful messages (e.g., USE CAUTION). Police and Fire agencies appear to be less able to subjectively assess the effectiveness of incident messages.
- Short simple phrases are preferred, but symbolic messages may be used to prevent drivers from spending too much time looking at the message. It seems that eliminating the need to read a message by using symbols is a preferred option, but this approach is likely much more complicated than using language. In any case, symbolic messages are often paired with language in practice. There may be some opportunities to combine symbols with effective informational phrases.
- There are complex traffic management issues that result from incidents that do not lend to an obvious preventative or mitigating solution. There is no obvious easily deployable solution to eliminate problems associated with rubbernecking, other than completely occluding the incident scene (e.g., the incident screens used in Europe).
- When diverging traffic from an incident it is easier to force all traffic into one lane (e.g., MERGE LEFT/RIGHT, or USE ALT. ROUTE) than to provide optional travel paths.
- The symbolic message for merging traffic may be unclear to drivers. An alternative worth testing is using the shift arrow for reverse curves.
- The IR Groups provided the rationale for a select number of messages and it was evident that the rationale behind the use of current messages is lacking.

### GP Groups Summary

The summary statistics for the GP groups show that there was an overwhelming preference for action phrases to provide information on diversions like rerouting, and merging around incident locations. Similar to the IR groups, the GP Groups showed a preference for simple messages that consist of few IUs. More than half the messages were repeated within the GP groups and this likely resulted from a combination of multiple factors, including: their prominent use of example phrases provided in the instruction book; their repeated use of messages across scenarios as per our request for generalizable messages; and the cooperative nature the GP group used to generated messages. Although the GP group responded overwhelmingly by

writing in the response book, it is very likely that many of their individual responses were a result of collaborative thinking. Regardless, the trend for action phrases and short messages is insightful and supported with their discussion points. A few notable discussion points are described below.

- The majority of discussion was on providing drivers with information on the actions afforded to them by the traffic control devices, which was best described with a few pertinent quotes noted in the results.
- Early, upstream diversion messages are important. There was a large amount of discussion on messaging for diverting drivers away from the incident.
- There was logical discussion regarding the use and value of general messaging (e.g., EMERGENCY SCENE AHEAD). Their discussion may imply some degree of acceptance and understanding of general messaging.
- The brief discussion on the use of technology solutions may provide insight on acceptance of other methods of presenting information. The GP Group stated that they thought broadcast options like radio and internet were more viable options to receive relevant traffic information.

# CHAPTER 5. COMPREHENSION STUDY

Evaluations of driver comprehension of traffic signs have investigated symbols, pictographs and pictograms and verbal messages (e.g., Charlton [5]; & Ells & Dewar [11]). Similar to other types of traffic events, the messages for traffic incidents consist of verbal messages and symbols. The message options we investigated for the comprehension study discussed in this chapter consisted of both verbal and symbolic elements.

There were two goals supporting the comprehension study, one goal was to identify a generalizable set of traffic incident legends and symbols that drivers comprehend as signifying a traffic incident. The second goal was to evaluate a sub-set of these messages to gain insights on the driver actions they promote. General standard traffic control messages and non-standard incident messages were included in our evaluation. The non-standard messages were generated using findings from the previous tasks in this project.

The degree that people agree that an icon and message are associated with the concept it represents (e.g., Semantic Closeness) has been found to be highly correlated with comprehension [22]. For our first study we used a semantic matching task to evaluate how well a large set of messages would be associated with representative traffic situations. The data from the matching task demonstrate the semantic linkage between the message and its referent. We intentionally muddled this linkage by eliminating the standard color coding, including a wide array of signs, and a narrow set of referent situations. Our main interest was the degree that messages were associated with traffic incidents; the alternative referents were included to assess the how well people assigned messages to traffic incidents given alternative options that were different (e.g., crosswalks) and similar (e.g., road construction) to traffic incidents. These options increased task difficulty. We computed a percent agreement per sign per situation for all the participant responses to provide an understanding to the degree people associated relevant messages to traffic incidents. Research has also found cross-cultural differences with how well drivers understand the meaning of signs, which likely corresponds with differences in driver training provided in various countries [26], we made sure to record where our participants learned to drive.

The goal of our second study was to evaluate driver actions associated with messages for traffic incidents, and we used an open-ended response paradigm to accomplish this goal. Open ended response methods have been used to evaluate how well people understand in-vehicle icons like tell-tales for vehicle system notifications [3]. Other researchers have used the same method to the evaluate comprehension of existing and novel road signs (e.g., Ben-Basset & Shinar [2]; Shinar et al., [26]; & Creaser et al., [7]). Our approach was slightly unique in that we were interested in driver actions. This method typically requires developing evaluation criteria for rating responses, which are used to determine different levels of understanding the intended meaning of the icon or test symbol (e.g., understands perfectly, somewhat or not at all). Responses are then evaluated and rated based on the criteria by a team of researchers, which are then tested for inter-rater agreement. An SAE J2830 [25] report was published in 2008 that describes this procedure. To accomplish our task, we asked participants to describe, in an open ended manner, the driving actions that they would take if they were to encounter specific messages at a traffic incident in the real world. We paired a select set of traffic messages with representations of traffic incidents and asked participants to describe the driving actions that they would act out.

To analyze their responses, we searched for and counted the frequency of common relevant keywords. When viewed across the full array of participant responses, the keywords can provide perspective on the driver actions that were most commonly associated with each message that was included in Study 2.

The methods and results of both studies are discussed in the following sections.

## METHODS FOR STUDY 1

The comprehension study was carried out using a paper-based testing protocol. A response book was used to collect responses. Battelle's IRB reviewed and approved our approach (Appendix J) which is discussed as follows: 1) *Participants*, 2) *Materials*, 3) *Procedures* and 4) *Analysis*.

### Participants for Study 1

Participants were recruited using Craigslist.org. The recruitment advertisement is shown in Appendix K. A total of 67 drivers from the general public participated (31 male, 35 female; Age = 42, SD = 13.5). The average number years a participant had their driver's license was 25 (SD = 13.4). Sixty-Six participants learned to drive in the United States, and one participant learned to drive in Canada. Participants received $25 for their participation. Participant reported education level and annual household income are shown in Figure 16 and Table 17.

**Table 16. Participant education level.**

| Education Level Categories | n |
|---|---|
| Below 12th grade | 0 |
| High School diploma | 1 |
| Some College | 9 |
| Associates Degree | 6 |
| Bachelor's Degree | 39 |
| Advanced Degree | 12 |

**Table 17. Participant annual household income.**

| Income Categories | n |
|---|---|
| Under $20,000 | 10 |
| $20,000 - $39,999 | 11 |
| $40,000 - $59,999 | 16 |
| $60,000 - $79,999 | 11 |
| $80,000 - $99,999 | 10 |
| $100,000 or greater | 9 |

### Materials for Study 1

The response book contained demographic questions and instructions, images of legends and symbols shown on signs, representations of reference groups for matching with the messages, and space for participants to write their responses. There were forty-one messages that were either a legend or symbol. Messages were selected that represented topics from the focus group discussion and discussions with SMEs (e.g., the need to encourage drivers to reroute on their own without additional guide signs). There was a set of twenty-nine messages taken from the MUTCD 2009 (Figure 10 to Figure 38). There were nine non-standard messages; of those, one was created using expert judgment (Figure 39), eight were pulled from the results of the Focus Groups (Figure 40 to Figure 47). There were three messages from the European Union (Figure 48, Figure 49, & Figure 50).

The majority of the messages were of interest to the purpose of this project (test-messages) Additional messages that were not germane served as foils and were inserted to aid in obtaining valid responses. Legends and symbols were shown in the foreground within a gray sign shape that had a black border. The purpose of use of the gray-scale coloring was to prevent participants from grouping signs based on their color. The legends were printed in black, Arial Narrow font and the letters were bold.

The contents of EM-2, EM-3, and EM-4 (Figures 5-1, 5-2 & 5-3) were included as test-messages due to the definitions of use in the MUTCD for emergency events that need traffic control – e.g., to limit congestion, expedite emergency traffic, exclude unauthorized vehicles, protect the public, or for traffic stops.


**Figure 10. EM-2 (modified [13]).**


**Figure 11. EM-3 (modified [13]).**


**Figure 12. EM-4 (modified [13]).**

The contents of W1-1a, W1-2a and W1-11(Figure 13, Figure 14, & Figure 15) served as foils for the reference group on horizontal road curvatures. These are typically placed in advance of turns and curves that may also have advisory speeds. The reverse curve symbol (W1-4) in Figure 16 was included as a test-message because the Focus Groups conclusions show that incident responder thought that it may serve as a better guidance sign compared to the Lane Ends symbol (W4-2) in Figure 17, which is commonly used for TIM and is shown in MUTCD chapter 6i. The MUTCD states that the reverse curve (W1-4) provides information on changes in road alignment. It is thought that similar guidance information may be useful in TIM.


**Figure 13. W1-1a (modified [13]).**


**Figure 14. W1-2a (modified [13]).**

**Figure 15. W1-11 (modified [13]).**

**Figure 16. W1-4 (modified [13]).**

**Figure 17. W4-2 (modified [13]).**

The contents of W3-1, W3-2, and W3-5 were included as test-messages due to their defined use. The MUTCD describes them as multi-purpose signs and indicates that any of these could be used as advance traffic control signs or as a warning sign for TTC (Figure 18, Figure 19 & Figure 20).

**Figure 18. W3-1 (modified [13]).**

**Figure 19. W3-2 (modified [13]).**


**Figure 20. W3-5 (modified [13]).**

Pedestrian crossing signs (S1-1 and S11-2) and a non-vehicular warning (S11-9) served as foils (Figure 21, Figure 22, & Figure 23). These messages allowed for the use of the pedestrian crosswalk group, which served as a foil group to legitimize the sorting task.


**Figure 21. S1-1 (modified [13]).**


**Figure 22. W11-2 (modified [13]).**

**Figure 23. W11-9 (modified [13]).**

The symbol in R3-27 was included as a test-sign due its general purpose look and its recommended use, which is to prohibit a road user in a specific lane from proceeding straight (Figure 24). The legend in W19-5 (Figure 25) served as a test sign because has a similar connotation in that it also indicates that road users cannot continue straight. Both messages correspond with the focus group results, which indicated that incident responders close roads and leave it up to the drivers to figure out alternate routes.

**Figure 24. R3-27 (modified [13]).**


**Figure 25. W19-5 (modified [13]).**

The legends in W9-3, R11-2 and E5-2 (Figure 26, Figure 27 & Figure 28) were used as test messages because of their real-world use (e.g., to prohibit traffic from entering roadway areas) and due to incident responders providing substantial discussion about the term “Closed”. The responders stated that “Closed” is more effective than other similar terms like, “Blocked” as in ROAD BLOCKED. An additional purpose for inclusion of W9-3 and E5-2a is that both are shown in the MUTCD as warning signs for general TTC and in chapter 6i for TIM.


**Figure 26. W9-3 (modified [13]).**


**Figure 27. R11-2 (modified [13]).**


**Figure 28. E5-2a (modified [13]).**

The legends in R3-27, R4-1, R4-3, R14-3 and R4-9 (Figure 29 through Figure 33) were included as test-messages because they align with incident responders need for a message or set of messages that aid in keeping road users from diverting around their traffic control devices. These legends imply that road users should stay in their current driving lane.


**Figure 29. R3-5a (modified [13]).**


**Figure 30. R4-1 (modified [13]).**


**Figure 31. W4-5P (modified [13]).**


**Figure 32. R4-9 (modified [13]).**


**Figure 33. W14-3 (modified [13]).**

The legends for M4-8a and W3-4 were included because they are shown in chapter 6i of the MUTCD (Figure 34 & Figure 35). Additionally, the legend in W3-4 received a lot of discussion during the focus groups. The general public and incident responder focus groups made comments implying that the message is superfluous.


**Figure 34. M4-8a (modified [13]).**


**Figure 35. W3-4 (modified [13]).**

Legends W23-2, R4-3 and the symbol in W20-7a served as foils to bring validity to the construction reference group (Figure 36, Figure 37, & Figure 38).


**Figure 36. W23-2 (modified [13]).**


**Figure 37. R4-3 (modified [13]).**

**Figure 38. W 20-7a (modified [13]).**

The nine messages in Figure 39 through Figure 47 were generated using focus groups discussion and expert judgment.

**Figure 39. Location mark W1-4 (modified [13]).**


**Figure 40. Non-directional W9-2 (modified [13]).**


**Figure 41. Crash ahead (Battelle).**


**Figure 42. Incident management (Battelle).**


**Figure 43. Fire activity (Battelle).**


**Figure 44. Slow traffic ahead short (Battelle).**


**Figure 45. Traffic Emergency Ahead (Battelle).**


**Figure 46. Slow traffic long (Battelle).**


**Figure 47. Reduce speed (Battelle).**

Traffic messages used in the European Union were included. The symbols in Figure 48 served as a foil to compliment the pedestrian crosswalk group. The images in Figure 49 and Figure 50 were included as test-messages to for comparison to MUTCD signs and novel signs.

**Figure 48. EU pedestrian crosswalk[12].**

**Figure 49. EU accident or danger[12].**

**Figure 50. EU traffic jam[12].**

**Study 1 Procedures**

Participants were provided a briefing form when they arrived (See Appendix L) and were given an opportunity to ask questions. Then they were told to review the response book and that the instructions for the tasks they were completing were in the book. An experimenter was present to answer questions throughout all the study sessions. Using the response book, first they completed the demographic questions, then Study 1 followed by Study 2.

For study 1, Participants were told to select one out of the five reference groups that best matched a message. They were shown one message at a time. The presentation order was randomized once and remained the same for each participant. The same 5 reference groups were used for each message. A single response per message per participant ensures noticeable variability in comprehension and allows for assessing generalizability. If participants were allowed to select more than one reference group, the variability would be less apparent and it would be more difficult to compute differences across the messages.

For study 1, there were five reference groups provided to participants to complete the matching task. The reference groups represented various relevant situations described in the MUTCD that require signage, again we wanted to see how many signs were assigned to traffic incidents. The groups are listed below, and participants were shown non-text representations of each group labeled as Group A, B, C, D, or E without the adjacent keyword shown below:

| | |
|---|---|
| **Group A (Curves):** | Horizontal road curvatures, including representations of simple, hairpin, serpentine, reverse curve. |
| **Group B (Incidents):** | Traffic incidents on shoulder, middle lane bock, partial roadway blocked, with emergency responders present (i.e., police, fire, towing). |
| **Group C (X-Walk):** | Pedestrian crosswalks at intersections. This reference group served as a foil |

| | |
|---|---|
| **Group D (Advance):** | Approaching a low visibility primary traffic control device (i.e., situations that require advance yield, stop and speed signs). |
| **Group E (Roadwork):** | Roadway construction zones with barrel tapers, equipment and lighting. |

Participants were provided the instructions below for Study 1

> *Following the example below, we want you to look at the traffic sign, then look at the groups and decide which group seems to match the sign. Please match the sign to the group that seems to have the strongest association.*
>
> *Traffic Sign: A sign will be shown in black and white at the top of each page. A different sign will be shown on each page*
>
> *Groups: Groups will be shown under the traffic sign. Each group shows pictures of roadway situations that are very similar. These situations require special signs. There are 5 groups. The groups will be the same on each page.*
>
> *Response bubbles: Each group has a response bubble. Respond by filling in or checking off the bubble for the group that seems to best match the sign.*
>
> *Be quick and as accurate as possible with your responses. We are trying to capture your initial impression as if this is the first time you've seen this sign.*
>
> *If you were really driving and saw a road sign like this you would only have a moment to figure out what the message means.*
>
> *If you find that you are spending too long on a sign and are not too sure about which group to select, it is OK to guess.*

The data from one participant was excluded from Study 1 as a result of improper responses to all test items. Additionally, there were twelve individual responses that were excluded due to a subset of participants who provided more than one response for one or more test items. The data from 66 participants were included.

### Analysis for Study 1

The data from Study 1 were tabulated by counting the number of responses per message per category and computing percentages of responses for each message. The results are discussed following the description of the Study 2 methods in the results section.

## METHODS FOR STUDY 2

The study on driver actions was carried out using a paper-based testing protocol. A response book was used to collect responses; this was an attachment to the Study 1 response book. The following discusses: 1) *Participants*, 2) *Materials*, 3) *Procedures* and 4) *Analysis* for study 2.

## Participants for Study 2

The same group of participants from Study 1 completed Study 2.

## Materials for Study 2

Study 2 consisted of a subset of eleven messages from Study 1 that captured diversion, prohibiting traffic, and standard messages. These signs are shown in, Figure 16, Figure 17, Figure 24, Figure 30, Figure 32, Figure 45, Figure 39, Figure 41, Figure 42, Figure 46, Figure 50. The limited range of messages in Study 2 was due to the resource intensive requirements of depicting the traffic incidents and reducing the data.

## Study 2 Procedures

For Study 2, participants were shown message/incident pairs, which were described to them as a "sign and a situation" to avoid leading them to bias their responses towards incidents. They were shown 11 different pairs of messages and incidents. Prior to starting study 2, participants were given the instructions below:

> *You will be shown a sign and a situation. Your task is to describe what actions you would take as a driver if you saw the sign in the real world. Some of the signs have words and some have symbols. The information on some signs may be easier to figure out compared to others.*
>
> *An example of the layout of this study is shown below. On each page there is a question and brief instructions at the top, a sign and traffic situation, and an area to respond. There is a red arrow for the traffic situation to show the direction that you would be traveling.*
>
> *For your response, briefly describe what you would do once you have a sense for what the sign is suggesting. To respond, please finish the sentence that shown in the response box below.*

For each message/incident presentation there was an instruction that stated, "What would you do when you see this sign? Imagine you are driving along the highway. You see the sign and the traffic situation shown below and have to decide what to do." There was also a leading instruction on how to phrase responses. A blank region was provided under the following phrase, "Finish the sentence in the space below to describe what actions you would take as a driver after seeing the sign." The sentence they were required to finish was, "*Using the information from the sign I know that I should…"*

After completing Study 2, participants received $25 as an incentive for their participation and were dismissed.

## Analysis for Study 2

To efficiently analyze the open-ended responses in Study 2, a set of keywords were identified that allowed for an expedient analysis of the majority (87.7%) of the large set of responses

provided by participant. The keywords were used to quantify the frequency of use for relevant terms to describe driver actions. The frequency of any of the keywords per message provides insight into the degree the driver actions are associated with each message.

This type of analysis required converting each response into a data string, and using a formula to search within the string for sub-strings. The substrings were created using the keywords shown in Table 18. Keywords were grouped into thematic keyword categories to allow for efficient discussion of the results. Keywords were grouped and turned into a list with an "OR" operator between each term, which was then used as an index for the formulas that evaluated the responses. The formulas counted the occurrence of terms in each of these lists across all responses per message. This method provided counts of Change Route, Crash Ahead, Continue Diversion Attentiveness, Slow/Delay and Sign Phrases keywords for each message. To calculate the relative use of each set of keywords per message, we summed the overall use of all keywords per message. The keyword use per message and counts per keyword category per message were used to compute a relative use of keywords per message per keyword category. Multiple keyword categories per message were tallied to capture responses that described multiple driver actions.

Note, root words were used for several keywords to ensure word endings (e.g., -s, -ed, -er, -ing, -ation, etc.) did not create a bias for excluding relevant responses. For example, the root "Merg" was used to make sure the following terms were not excluded: merges, merger, merging, etc. These keywords are marked with an asterisk in Table 18.

**Table 18. Keyword Categories**

| Keyword Category | Keywords in Category |
|---|---|
| Change Route | "Detour" OR "Route" OR "Exit" OR "Direction" |
| Crash ahead | "Crash" OR "Accident" OR "Collision" OR "Emergency" |
| Continue | "Prepare" OR "Prepared" OR "Continue" OR "Not Chang*" |
| Diversion | "Merg*" OR "Change lane" OR "Mov*" OR "Pass" OR "Go around" |
| Attentiveness | "Care" OR "Alert" OR "Aware" OR "Atten*" OR "Caut*" OR "Avoid" |
| Slow/Delay | "Slow" OR "Delay" OR "Wait" OR "Stop" |
| Sign Phrases | "Be Prepared to stop" OR "Stay in lane" OR "Stay in my lane" OR "Do not pass" |

## RESULTS

This section provides an analysis of the results of Study 1 and Study 2.

### Results of Study 1

This section describes the results of Study 1. It analyzes how participants matched messages to reference groups. The percentages reported in the results are of the total sample of participants (n = 66) unless otherwise noted.

Participants assigned the foil messages into the anticipated categories with a high degree of consistency, which implies that participants were conscientious to the task (Table 19). The majority of participants (M = 90%, SD = 7%) assigned the road curve messages W1-1a, W1-2a and W1-11 to Group A, which is reasonable because it represents road curves. The majority of participants (M= 99%, SD =1%) assigned the cross walk messages S1-1, W11-2, W11-9 and EU Pedestrian to Group C, which represented crosswalks. The majority of participants (M=69%, SD = 2%) assigned foil messages for roadway construction zones W23-2, R4-3 and W20-7a to Group E, which represented roadway construction zones. The foil messages we expected to be assigned to Group E show more variation in assignment compared to the messages assigned to Groups A and B. This result is acceptable given the similarity between messages for roadway construction and other types of traffic control.

Table 20 shows the groups that participants assigned to standard test-messages. Our primary interests are the degree to which messages were assigned to Group B, which represented traffic incidents. There was not a lot of agreement within Group B overall. The average percent agreement within Group B across all the standard test-messages was low (M = 18%, SD =18%). Despite this result, it is of interest to highlight a few of the signs that had percentages that were one or more standard deviations higher than the mean.

**Table 19. Results for the Foil Messages**

| Label | Comparison Group | Group A (Curves) | Group B (Incidents) | Group C (X-walk) | Group D (Advance) | Group E (roadwork) |
|---|---|---|---|---|---|---|
| W1-1a | Group A | 95% | - | 2% | 2% | 2% |
| W1-2a | Group A | 94% | - | - | 5% | 2% |
| W1-11 | Group A | 82% | - | - | 15% | 3% |
| S1-1 | Group C | - | - | 98% | - | 2% |
| W11-2* | Group C | 2% | - | 98% | - | - |
| W11-9 | Group C | - | - | 98% | - | 2% |
| EU–Ped | Group C | - | - | 100% | - | - |
| W23-2 | Group E | - | 2% | - | 27% | 71% |
| R4-3 | Group E | 6% | 6% | 2% | 20% | 67% |
| W20-7a* | Group E | - | 15% | 15% | - | 69% |

*Notes:* *Messages with 65 analyzed responses.

The majority of participants assigned the EU Exclamation Mark consistently to Group B (61%). This result implies there was a general understanding that the EU Exclamation mark can represent traffic incidents. EM-2 was assigned to Group B (51%) and Group E (46%) often, which implies there is some moderate general understanding for its use for traffic incidents and roadway construction. Similarly, participants often assigned R3-27 to Group B (42%) and Group E (35%), which implies general understanding for its use in both traffic incidents and road construction. It is important to point out that EM2, EM-4 and R3-27 are not associated with traffic incidents or construction in the MUTCD [13]. The results from this study may imply these signs could be expanded beyond their original use. It's worth noting that although W19-5 carries the same connotation as R3-27 participants did not assign it to Group B at all. This result may suggest there is some value in the use of iconographic prohibitory messages. The ROAD

CLOSED legend for R11-2 also has notable results. Although the majority of participants assigned this legend to Group E (55%) there was moderate tendency to assign it to Group B (35%). Again, the need to use the term "Closed" was a topic from the Incident Responders during the focus group activity. This result implies that there is some general understanding that ROAD CLOSED would be used for traffic incidents.

The results for messages from Chapter 6i of the MUTCD require some attention (these are bolded in Table 20). W4-2 was rarely assigned to Group B (6%), and W9-3 (22%), E5-2a (17%) and W3-4 (27%) were assigned to Group E disproportionality more often (63%, 76% and 42%, respectively). The disproportionate assignment of these messages to Group E is not unreasonable given the high degree of similarity between traffic incidents and construction, and that people have lower exposure to traffic incidents. The data show a slight bias toward assigning the standard test-messages to Group E. Participants assigned the standard test-messages to Group E more (M = 44%, SD = 21%) compared to any of the other groups.

**Table 20 Standard Test-message and Symbols. (Bolded rows from MUTCD 6i.[13])**

| Label | Comparison Group | Group A (Curves) | Group B (Incidents) | Group C (X-walk) | Group D (Advance) | Group E (roadwork) |
|---|---|---|---|---|---|---|
| EM-2* | Group B | - | 51% | 0% | 3% | 46% |
| EM-3 | Group B | - | 21% | 2% | 17% | 61% |
| EM-4 | Group B | 45% | 6% | 0% | 20% | 29% |
| W1-4 | Group B | 35% | 5% | 0% | 20% | 41% |
| **W4-2** | **Group B** | **6%** | **6%** | **0%** | **20%** | **68%** |
| W3-1 | Group B | 2% | 3% | 15% | 74% | 6% |
| W3-2 | Group B | 5% | 9% | 20% | 45% | 21% |
| W3-5* | Group B | 18% | - | - | 34% | 45% |
| R3-27 | Group B | 6% | 42% | - | 17% | 35% |
| W19-5 | Group B | | - | 45% | - | 18% |
| **W9-3*** | **Group B** | **-** | **22%** | **-** | **15%** | **63%** |
| R11-2 | Group B | - | 35% | - | 9% | 55% |
| **E5-2a** | **Group B** | **-** | **17%** | **2%** | **6%** | **76%** |
| R3-5a | Group B | 12% | 5% | 2% | 21% | 61% |
| R4-1 | Group B | 73% | 3% | 0% | 3% | 21% |
| W4-5P | Group B | 39% | 5% | 5% | 15% | 36% |
| R4-9* | Group B | 25% | 3% | - | 20% | 52% |
| W14-3 | Group B | 85% | 2% | - | 6% | 8% |
| M4-8a | Group B | - | 6% | - | 14% | 80% |
| **W3-4**** | **Group B** | **-** | **27%** | **5%** | **27%** | **42%** |
| EU–Exclamation Mark** | Group B | 2% | 61% | 8% | - | 30% |
| EU–Heavy Traffic | Group B | 2% | 14% | - | 12% | 73% |

*Notes:* * Messages with 65 responses, ** Messages with 64 responses.

Table 21 shows the groups that participants assigned to non-standard test-messages. Our primary interests for the non-standard test-messages are the extent that participants assigned them to Group B, which represented traffic incidents. Again, these messages were included because of the results of the previous tasks for this project and they pertain exclusively to traffic incident management issues identified by SMEs, incident responders and the general public.

The data show there was moderate agreement assigning non-standard test-messages to Group B. Participants were more likely to assign these messages to the traffic incident group compared to the Standard Test-messages. The average percent agreement within Group B across all the standard test-messages was near a majority value (M = 49%, SD = 44%), with a high degree of variance. The high variance is mostly from the four messages that were rarely assigned to Group B (Location mark W1-4¸ Non-directional W9-2, Slow traffic ahead short, Reduce speed). The legends CRASH AHEAD, INCIDENT MANAGEMENT, FIRE ACTIVITY, and TRAFFIC EMERGENCY AHEAD were almost always assigned to Group B (98%, 95%, 88%, & 95%, respectively). These legends contained text that used terms associated with traffic incidents, which likely influenced their consistent assignment to the traffic incident group.

There was also a strong bias to assigning nonstandard test-messages to Group E, which represented roadwork scenes. However, the tendency to assign messages to this group was lower for Group E (M = 40%, SD = 31%) than for Group B. Again, this result is reasonable. Given that roadwork events are more common than traffic incidents, a response bias toward assigning messages to the roadwork group was expected.

**Table 21. Results for the Nonstandard Test-messages.**

| Label | Comparison Group | Group A (Curves) | Group B (Incidents) | Group C (X-walk) | Group D (Advance) | Group E (Roadwork) |
|---|---|---|---|---|---|---|
| Location mark W1-4 | Group B | 38% | 5% | 2% | 18% | 38% |
| Non-directional W9-2 | Group B | - | 11% | - | 20% | 70% |
| Crash ahead | Group B | - | 98% | - | 2% | - |
| Incident management | Group B | - | 95% | - | - | 5% |
| Fire activity | Group B | 2% | 88% | - | 2% | 9% |
| Slow traffic ahead long** | Group B | 2% | 30% | - | 11% | 58% |
| Slow traffic ahead short* | Group B | 2% | 8% | - | 6% | 85% |
| Reduce speed** | Group B | 33% | 9% | 2% | 8% | 48% |
| Traffic Emergency Ahead | Group B | - | 95% | 2% | - | 3% |

**Summary Conclusions of Study 1**

This section summarizes pertinent findings from the results of study 1.

The results of Study 1 show that some standard messages were understood as being associated with traffic incidents, although the agreement was only moderate across participants. The highest agreement was shown for the EU exclamation mark (Figure 51). There were a select group of standard messages from the MUTCD [13] that also had high agreement; these were the EU exclamation point, the EM-2 AREA CLOSED (Figure 52), and R3-27 Prohibited forward travel (Figure 53) messages.

**Figure 51. EU accident or danger[12].**


**Figure 52. EM-2 (modified [13]).**

**Figure 53. R3-27 (modified [13]).**

There was greater agreement across the nonstandard messages associating them to the traffic incident group. It is important to highlight that the messages from the nonstandard group that contained language were assigned to the traffic incident group by almost every participant (e.g., CRASH AHEAD, INCIDENT MANAGEMENT, FIRE ACTIVITY, and TRAFFIC EMERGENCY AHEAD, Figure 54 through Figure 57).


**Figure 54. Crash ahead (Battelle).**


**Figure 55. Incident management (Battelle).**


**Figure 56. Fire activity (Battelle).**


**Figure 57. Traffic Emergency Ahead (Battelle).**

The result that the EU exclamation mark had favorable results for traffic incidents shows that simple markings may be useful; in Study 1 the exclamation mark was more useful than the "X" that was used to modify the reverse curve symbol to create an incident message. The modified reverse curve (e.g., Location mark W1-4) and the original reverse curve were associated with both construction zones and road curves, but not traffic incidents. This result seems to suggest that the addition of the "X" was not a defining factor, and not a factor that lead to an association with traffic incidents. There cannot be a strong conclusion made regarding the usefulness of the "X" as a result of the low overall agreement. Both the modified and unmodified signs maximum agreement percentage was modest (e.g., 38% and 41%), which suggests there was some agreement across participants, but the agreement for the other messages discussed in the above paragraph is greater. The greater agreement leads to clearer conclusions that those messages can be understood to represent traffic incidents.

These results suggest that messages that contain clear terminology regarding a traffic incident will be associated with a traffic incident with a high degree of consistency. It was outside the

scope of this study to determine the extent that it is important to indicate to drivers that they are approaching an incident. If this is found to be relevant information for approaching drivers, general statements (e.g., "Traffic emergency ahead") will likely be sufficient.

The results of Study 1 suggest the following:

- The use of concise language can be effective at getting drivers to associate a traffic control legend with a traffic incident.
- Legends may be associated with traffic incidents with less consistency if they are not clearly marked with a concise phrase or term to indicate there is a traffic incident.
- There may be a high degree of association between traffic messages and road construction, but we conclude that the association is justifiable given the critical similarities between road construction and traffic incidents. In both cases, there are personnel that are exposed to traffic.

**Results of Study 2**

This section describes the overall results of Study 2. It analyzes the driver actions associated with each message. The lists of keywords that were selected for this evaluation were able to capture the majority of the open-ended responses. There were 737 responses provided by participants and the keywords were used in 647 of these responses. Thus, there were 90 responses that did not contain one of our keywords and were not part of the subsequent evaluation. Of the total evaluated responses, there were 7,769 words and 1,190 of them were keywords. Table 23 shows the count of keywords per message and keyword category.

Of all the keywords, those that belong in the Slow/Delay category were used the most with 32% of the total count of keywords, followed by the Diversion category with 23%. Of interest, the less frequent use of terms from the change route category suggests that the messages in Study 2 (a subset of messages used in study 1) were less able to influence descriptions of driver actions that would result in rerouting. However, there was one message that was associated with a moderate use of Change Route keywords (e.g., R3-27 Prohibited Forward Travel symbol)

**Table 22. Overall Keyword Use Across All Descriptions**

| Category | Percent Use |
|---|---|
| Change Route | 6% |
| Crash Ahead | 12% |
| Continue | 12% |
| Diversion | 23% |
| Attentiveness | 10% |
| Slow/Delay | 32% |
| Sign Phrases | 6% |

To show how the keyword terms were used to describe driver actions associated with each message**,** the keyword categories distributions are shown for each of the eleven messages. In the subsequent pages, tables for each message are shown with percent-use values for the 7 keyword categories.

The results for each message are presented in Table 24 to Table 34. The discussion for each message focuses on the majority of keyword categories used to describe the driver actions for that message. A majority was determined using the first keyword categories that had a combined value that summed to greater than 50% (e.g., the first two or more categories that had a percent use that summed to greater than 50%).

**Table 23. Count of Keywords (KWs) by Message**

| Label | Change Route KWs | Crash Ahead KWs | Continue KWs | Diversion KWs | Attentiveness KWs | Slow/Delay KWs | Sign Terms KWs | Subtotal |
|---|---|---|---|---|---|---|---|---|
| W1-4 Reverse Curve | 2 | 7 | 26 | 43 | 31 | 17 | 1 | 79 |
| W4-2 Lane Ends | 9 | 3 | 38 | 40 | 31 | 17 | 3 | 91 |
| R3-27 Prohibited Forward Travel | 32 | 6 | 13 | 4 | 40 | 7 | 1 | 86 |
| R4-1 DO NOT PASS | 7 | 9 | 51 | 41 | 22 | 11 | 28 | 108 |
| R4-9 STAY IN LANE | 1 | 7 | 59 | 31 | 23 | 13 | 17 | 90 |
| W1-4 Location Mark Reverse Curve | 4 | 23 | 22 | 36 | 40 | 22 | 0 | 104 |
| CRASH AHEAD | 20 | 22 | 27 | 13 | 49 | 35 | 4 | 131 |
| INCIDENT MANAGEMENT | 11 | 20 | 19 | 22 | 63 | 48 | 2 | 139 |
| TRAFFIC EMERGENCY AHEAD | 16 | 19 | 26 | 22 | 46 | 36 | 6 | 131 |
| SLOW TRAFFIC AHEAD BE PREPARED TO STOP | 2 | 14 | 28 | 21 | 63 | 47 | 4 | 137 |
| EU Traffic Jam | 1 | 14 | 28 | 27 | 35 | 26 | 2 | 94 |
| Subtotal | 105 | 144 | 138 | 271 | 115 | 385 | 68 | 1190 |

There were 79 keyword terms in the descriptions of the W1-4 Reverse Curve (Figure 16). The distribution of these keywords across the Keyword Categories (Table 24) shows that the majority (66%) were from two categories. Participants mostly used words from the Diversion (38%) and Slow/Delay (28%) categories to describe the Reverse Curve.

**Table 24. W1-4 Reverse Curve**

| Category | Percent Use |
|---|---|
| Change Route | 0% |
| Crash Ahead | 9% |
| Continue | 9% |
| Diversion | 38% |
| Attentiveness | 15% |
| Slow/Delay | 28% |
| Legend Phrases | 1% |

There were 91 keyword terms in the descriptions of the W4-2 Lane Ends symbol (Figure 17). The distribution of these keywords across the Keyword Categories (Table 25) shows that the majority (70%) were from two categories. Participants mostly used words from the Diversion (44%) and Slow/Delay (26%) categories to describe the Lane Ends.

**Table 25. W4-2 Lane Ends**

| Category | Percent Use |
|---|---|
| Change Route | 2% |
| Crash Ahead | 3% |
| Continue | 10% |
| Diversion | 44% |
| Attentiveness | 11% |
| Slow/Delay | 26% |
| Legend Phrases | 3% |

There were 86 keyword terms in the descriptions of the R3-27 Prohibited Forward Travel symbol (Figure 24). The distribution of these keywords across the Keyword Categories (Table 26) shows that the majority (73%) were from two categories. Participants mostly used words from the Slow/Delay (44%) and the Change Route (29%) categories to describe the Prohibited Forward Travel symbol. The usage of keywords from the Change Route category is the most prominent for this message across all the messages in Study 2.

**Table 26. R3-27 Prohibited Forward Travel**

| Category | Percent Use |
|---|---|
| Change Route | 29% |
| Crash Ahead | 7% |
| Continue | 12% |
| Diversion | 5% |
| Attentiveness | 2% |
| Slow/Delay | 44% |
| Legend Phrases | 1% |

There were 108 keyword terms in the descriptions of the R4-1 DO NOT PASS legend (Figure 30). The distribution of these keywords across the Keyword Categories (Table 27) shows that the majority (51%) were from two categories. Participants mostly used words from and the Diversion (36%) and the Legend phrases (15%) categories to describe the DO NOT PASS legend. Keywords from the attentiveness category were also moderately used (13%). The use of legend phrases suggests there was an influence of the language in the legend in the responses.

**Table 27. R4-1 DO NOT PASS**

| Category | Percent Use |
|---|---|
| Change Route | 2% |
| Crash Ahead | 8% |
| Continue | 6% |
| Diversion | 36% |
| Attentiveness | 13% |
| Slow/Delay | 7% |
| Legend Phrases | 15% |

There were 90 keyword terms in the descriptions of the R4-9 STAY IN LANE legend (Figure 32). The distribution of these keywords across the Keyword Categories (Table 28) shows that the majority (55%) were from two categories. Participants mostly used words from the Diversion (34%) and Slow/Delay (21%) categories to describe the STAY IN LANE legend. The keywords form the Legends phrases were also moderately used (19%) suggesting there was an influence of the language in the legend.

**Table 28. R4-9 STAY IN LANE**

| Category | Percent Use |
|---|---|
| Change Route | 0% |
| Crash Ahead | 8% |
| Continue | 11% |
| Diversion | 34% |
| Attentiveness | 7% |
| Slow/Delay | 21% |
| Legend Phrases | 19% |

There were 104 keyword terms in the descriptions of the modified W1-4 Reverse Curve that had the "X" to represent the location of the incident (Figure 39). The distribution of these keywords across the Keyword Categories (Table 29) shows that the majority (72%) were from three categories. Participants mostly used words from the Slow/Delay (27%), Diversion (23%) and Crash Ahead (22%) categories to describe the reverse curve with the location mark.

**Table 29. W1-4 Location Mark Reverse Curve**

| Category | Percent Use |
|---|---|
| Change Route | 2% |
| Crash Ahead | 22% |
| Continue | 9% |
| Diversion | 23% |
| Attentiveness | 17% |
| Slow/Delay | 27% |
| Legend Phrases | 0% |

There were 131 keyword terms in the descriptions of the novel CRASH AHEAD legend (Figure 41). The distribution of these keywords across the Keyword Categories (Table 30) shows that the majority (71%) were from three categories. Participants mostly used words from the Slow/Delay (37%), Continue (17%) and Crash Ahead (17%) categories to describe the CRASH AHEAD legend.

**Table 30. CRASH AHEAD**

| Category | Percent Use |
|---|---|
| Change Route | 14% |
| Crash Ahead | 17% |
| Continue | 17% |
| Diversion | 9% |
| Attentiveness | 3% |
| Slow/Delay | 37% |
| Legend Phrases | 3% |

There were 139 keyword terms in the descriptions of the novel INCIDENT MANAGEMENT legend (Figure 41). The distribution of these keywords across the Keyword Categories (Table 31) shows that the majority (60%) were from two categories. Participants mostly used words from the Slow/Delay (44%) and Diversion (16%) categories to describe the INCIDENT MANAGEMENT legend. Keywords from the Crash ahead category were also prominent (14%).

**Table 31. INCIDENT MANAGEMENT**

| Category | Percent Use |
|---|---|
| Change Route | 3% |
| Crash Ahead | 14% |
| Continue | 12% |
| Diversion | 16% |
| Attentiveness | 10% |
| Slow/Delay | 44% |
| Legend Phrases | 1% |

There were 131 keyword terms in the descriptions of the TRAFFIC EMERGENCY AHEAD legend (Figure 45). The distribution of these keywords across the Keyword Categories (Table 32) shows that the majority (65%) were from three categories. Participants mostly used words from Slow/Delay (33%), Diversion (17%) and Crash Ahead (15%) categories to describe the TRAFFIC EMERGENCY AHEAD legend.

**Table 32. TRAFFIC EMERGENCY AHEAD**

| Category | Percent Use |
|---|---|
| Change Route | 11% |
| Crash Ahead | 15% |
| Continue | 14% |
| Diversion | 17% |
| Attentiveness | 7% |
| Slow/Delay | 33% |
| Legend Phrases | 5% |

There were 137 keyword terms in the descriptions of the SLOW TRAFFIC AHEAD BE PREPARED TO STOP legend (Figure 46). The distribution of these keywords across the Keyword Categories (Table 33) shows that the majority (72%) were from three categories. Participants used words from the Slow/Delay (42%), Diversion (15%) and Attentiveness (15%) categories.

**Table 33. SLOW TRAFFIC AHEAD BE PREPARED TO STOP**

| Category | Percent Use |
|---|---|
| Change Route | 1% |
| Crash Ahead | 10% |
| Continue | 14% |
| Diversion | 15% |
| Attentiveness | 15% |
| Slow/Delay | 42% |
| Legend Phrases | 3% |

There were 94 keyword terms in the descriptions of the EU traffic jam symbol (Figure 50). The distribution of these keywords across the Keyword Categories (Table 34) shows that the majority (58%) were from two categories. Participants used mostly words from the Diversion (29%) and Slow/Delay (29%) categories.

**Table 34. EU Traffic Jam**

| Category | Percent Use |
|---|---|
| Change Route | 0% |
| Crash Ahead | 15% |
| Continue | 13% |
| Diversion | 29% |
| Attentiveness | 13% |
| Slow/Delay | 29% |
| Legend Phrases | 2% |

**Summary Conclusions of Study 2**

This section provides a summary review of pertinent results from Study 2.

The descriptions of driver actions that participants provided for Study 2 predominantly had keywords that implied they would become aware of delays (e.g., wait, slow, delay, stop), and expect to make a diversion of some kind (e.g., merge, change lanes, move, pass.) for most legends and symbols. They rarely described changing their route. The exception was for the R3-27 Prohibitory forward travel symbol, which was described using a moderate amount of keywords that suggested participants would change their route if they encountered it in the real world.

The most informative result is the three-way comparison between reverse curve, lane ends and modified reverse curve. The addition of an "X" in the modified reverse curve (Figure 58) seems to have enhanced the association to the referent incident. To support its effectiveness, take note of the use of Crash Ahead keywords for the other tested legends or symbols. There were not many keywords from the Crash Ahead category in the description for the unmodified reverse curve symbol (9%) and the lane ends symbol (3%). There were more keywords from the Crash Ahead category for the modified reverse curve (22%) compared to any other legend or symbol; these are in addition to many keywords from the diversion and slow/delay categories. This result implies there may be awareness to lane change requirements and delays, in addition to awareness to the incident. This result suggests that an association between diversions and traffic incidents can be made when a message includes a diversion symbol (e.g., lane ends or reverse curve) and a representative symbol (e.g., "X").


**Figure 58. Location mark W1-4 (modified [13]).**

A similar result was found for the legends CRASH AHEAD, INCIDENT MANAGEMENT and FIRE ACTIVITY. These legends were associated with moderate usage of keywords from the Crash Ahead category. Similar to the results of Study 1, the use of concise language may have facilitated a stronger association between the legend and the incident.

The EU Traffic Jam symbol (Figure 59) from was associated with a high amount of keywords from the Diversion and slow/category, which suggests that it may prompt drivers to prepare for lane mergers

**Figure 59. EU traffic jam.**

The results of Study 2 suggest the following:

- The R3-27 Prohibitory forward travel symbol may show the most promise for rerouting traffic from an incident.
- The addition of a representative symbol (e.g., "X") may enhance the association between a legend or symbol and the incident.
- All test-messages and symbols serve a general purpose for enhancing awareness of potential delays. To the extent that enhancing awareness of delays is needed, the precise language in the legend may be of secondary importance.

## GENERAL CONCLUSIONS AND LIMITATIONS OF THE COMPREHENSION STUDY

This section discusses the conclusions of Studies 1 and 2 and the limitations associated with the conclusions.

### Conclusions

The results of both Study 1 and 2 conclude that the use of concise language can be effective at getting drivers to associate a traffic control legend with a traffic incident. Messages may be associated with traffic incidents with less consistency if they are not clearly marked with a concise phrase or term to indicate there is a traffic incident. There may be a high degree of association between traffic messages and road construction, but we conclude that the association is justifiable given the critical similarities between road construction and traffic incidents. In both cases there are personnel that are exposed to traffic.

The results for the modified reverse curve (i.e., W1-4 with an X) were mixed across study 1 and study 2. The addition of the "X" did not lead to distinguishing between the original message and the modified version, thus there was an inconclusive result for the methods used in Study 1 regarding the "X" marker concept. However, the results from Study 2 show a more conclusive result that the modified reverse curve was helpful for associating the message with the incident. The evidence for the benefit is shown with the high proportion of words that described the incident. Since there was a benefit found for the modified sign in the second study, a recommendation for testing this concept further is made.

The EU exclamation mark was associated with Traffic incidents relatively more than the other messages tested in Study 1. The result suggests that a case can be made for its use in traffic incident management. Additionally, given that the space requirements are similar to the "X" in the modified reverse curve, an exclamation mark could be used as a modifier for diversion messages for traffic incidents.

The results were in agreement from both studies for the R3-27 Prohibitory forward travel symbol. Study 1 showed an association with traffic incidents, and the results from Study 2 indicated that the symbol could lead to rerouting. Although this symbol is recommended in the MUTCD for lane control signs and plaques, the results from this research suggest that it could also be applied to traffic incident management signs.

Legends serve a general purpose for enhancing awareness of potential delays. To the extent that enhancing awareness of delays is needed, the precise language in the legend may be of secondary importance.

**Limitations**

The absence of driving context from Study 1 is a limitation. Driving context will lead to a stronger association between a traffic control device and its purpose or what it represents. We attempted to provide context in Study 2 by using representations of traffic incidents. This method allowed us to evaluate how well people could associate driver actions with messages, considering the ease and low cognitive demand of the study procedures the results may not transfer to real-word driving.

Presentation order is an additional limitation. To expedite data reduction effort, the paper-based method we chose did not use a fully random presentation order in either of the two studies. Thus, any effect of presentation order cannot be accounted in the analysis of the data. The fixed-random order we chose allowed for the expedient data reduction, which was required of the modest budget.

As a final limitation, the small sample size limits generalizability and repeatability. There is a chance a different sample of participants would result in dissimilar findings.

# CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This section discusses conclusions from the SME interviews, focus groups and comprehension study. Recommendations are included, and phrased for inclusion into the MUTCD. This section concludes with suggestions for future research.

## CONCLUSIONS

The discussions with the SMEs and incident responders during this project uncovered a need to separate traffic control guidelines and standard best practice for traffic control of traffic incidents from planned traffic events (e.g., road construction). Traffic incident management consists of numerous activities that are likely dissimilar from traffic management for planned traffic events. For traffic incidents there is a large degree of variability in how and when responders are notified of the event; the availability of resources in personnel and equipment depends on budgets, which can be severely constrained; the time it takes and the methods that are used for installation and removal of TTC depend on volumes of staff and equipment, which is often low; and the types of personnel providing and responsible for traffic control can vary depending on who is closest to the incident, when it happens and its severity (e.g., fire, or police, or fire-police, or response technicians). These functional factors that are different from other traffic events affect the feasibility of protecting first responders and the general public by providing traffic control for traffic incidents. However, there are important commonalties, relevant to the purpose of this project, among the traffic events that require temporary traffic control. For instance, the following needs logically remain consistent across all traffic events that require traffic control: guiding and informing road-users, preventing collisions, and keeping personnel safe. The similarities in the need to guide and inform road uses allow for a large degree of overlap in the messages provided to drivers, which was recognized and supported by the SMEs we interviewed, and the responders and people from the general public in the focus groups. The limitations for providing traffic control for traffic incidents is affected by the deployment issues outlined above, rather than the information provided to drivers and the messages used to communicate information, which do not seem to have many limiting factors. Responders recognize the value of traffic control and state that it would be more common if the logistical issues were resolved.

There are informal methods employed by agencies that could be included in future evaluations of TCDs and messages to drivers. SMEs and incident responders spoke of improvised TCDs. For instance, rural agencies experiment with placement to reduce the likelihood of drivers either destroying or removing their devices. They also developed portable cone mounted barricade devices and reported a high degree of efficiency and effectiveness. Additionally, some incident responders are able to informally assess the effectiveness of the messages that are deployed. Their measures of effectiveness are subjective but do lead to identifying useful messages (e.g., CRASH), or to excluding of less useful messages (e.g., USE CAUTION). Police and Fire agencies appear to be less able to subjectively assess the effectiveness of incident messages. The IR Groups provided the rationale for a select number of messages and it was evident that the rationale behind the use of current messages is lacking. In addition to being viable testing platforms, many of the agencies have tested out a variety of options and the results of their

informal testing may be insightful. Continued efforts to survey first responders could be very insightful.

A good example of the value of lesson-learned is the story from a response technician about transitioning from using verbal messaging to non-language based alerting (e.g., the flashing 4-corners). The notion that messages should be brief to reduce eyes-of-road reading times is one that persisted throughout the focus group, which became evident when the focus group message ideas were quantified. Responders and drivers from the general public support the use of short and informative messages. The effect that complex messaging has on drivers becomes evident to the responders who deploy the messaging and the drivers who rely on information from the messaging. Although, responders should be left with the flexibility to determine appropriate messaging for the type of incident that requires traffic control, they will likely benefit from an available set of options that have been tested and shown to have minimal negative impact on drivers.

It seems that eliminating the need to read a message by using symbols is a preferred option. Fortunately, the choice of symbols may not be too expansive, which leads to a more straightforward decision on the types of symbols to use in messages. For instance, the EU exclamation point showed favorable results in the comprehension study as it was the message with the most frequent associations to traffic incidents. Paring a symbolic messages with language is likely feasible. There may be some opportunities to combine simple symbols with effective informational phrases. For instance, there could be an effective message that contains the combination of 1) appropriate driver actions (e.g., reverse curve to indicate a lane merger) and 2) its association with the incident that requires modified driving action information (e.g., an "X" or the phrase "Incident Management").

There may be useful messages in other sections of the MUTCD [13] that could be included in guidelines for traffic incident management. For instance, EM-2 (i.e., AREA CLOSED) and R3-27 (i.e., prohibited forward travel) were associated with traffic incidents in the comprehension study but are not suggested for traffic incidents in the MUTCD. The results from this study may imply these could be expanded beyond their original use for lane control signs and plaques. The data for R2-37 shows agreement from both studies. Study 1 showed an association with traffic incidents, and the results from Study 2 indicated that it could lead to rerouting. The use of R3-27, which may be the clearest indication of a closed roadway or lane, could lead to an overall reduction in the personnel demands associated with installing an extensive rerouting system of TCDs. If drivers reroute on their own, without the need of additional wayfinding guidance, there will be significant cost savings compared to using a large amount of rerouting devices. The notion of letting drivers determine where to reroute was best phrased by a responding officer that participated in the focus groups when he said, "Drivers that formulate their own detour are preferable to us."

There were several additional concepts that were discussed by SMEs and first responders that are highly relevant, but lacked sufficient insights or criticality to lead to recommendations. These insights should be considered for future efforts to improve TIM. The following items should be considered for future research and evaluation:

- Test the effects of using cone or flare tapers to force traffic to reroute or to provide options for travel (e.g., the apex taper discussed in the focus groups).
- Testing alternative message displaying devices is recommended (e.g., the tri-pan folding signs mentioned during the SME interviews).
- Explore for alternatives to using a fire apparatus as a blocking device.
- Identify TCD placements that allow for on-coming traffic to by-pass the TCDs without removing or destroying them.

## RECOMMENDATIONS

The discussion points from the SMEs and incident responders that participated in this project allow the following recommendations for future editions of the MUTCD or other guidelines for traffic control for traffic incidents:

- Separate traffic control regulation, guidelines and standard best practice for TIM from all other forms of traffic control.
- Require the use of TTC devices that can be removed from an incident without placing personnel in travel lanes; an option for this could be to recommend the use of flares for creating traffic tapers, which can then be left to burn-out. Sufficient visibility testing for this use would need to be conducted (see Mesloh et al. [20]).

The data from this project allow for the following recommendations regarding messages for traffic incident management:

- Include the following terms as acceptable descriptors of incidents: CRASH AHEAD, INCIDENT MANAGEMENT, FIRE ACTIVITY, and TRAFFIC EMERGENCY AHEAD.
- Include MUTCD R3-27 (i.e., the prohibitory forward travel) as a potential message for traffic incident management rerouting.
- Include the EU exclamation as a potential symbol for representing a traffic incident.
- If a reverse curve is used, the addition of a representative symbol (e.g., “X”) can be used to enhance the association between the legend or symbol and the incident.

## SUGGESTIONS FOR FUTURE RESEARCH

Several research gaps were identified throughout the course of this project. Below is a list of research ideas.

- A requirement for legends to contain concise language or symbols that can be quickly viewed by road-users requires more research. Additional empirical studies should evaluate the association between legend length and complexity in pertinent crash situations (e.g., high traffic).

- The effectiveness of temporary adjustments to local speed limits near an incident is unknown but could be a promising countermeasure. If adjustments reduce the speed of upstream traffic it could lead to better traffic flow and fewer secondary incidents.

Drivers could be notified of speed changes through the use of temporary traffic signs with lower speed limits, which has not been fully explored for the short-term traffic incidents. Future research should empirically evaluated temporary changes to speed at incidents and assess if drivers adjust their speed.

- The observation that drivers in the EU activate their hazard lights when approaching a traffic incident may lend well to enhancing the awareness of other drivers when they approach traffic congestion resulting from an incident. It is not known if drivers in the US would activate their hazard lights when already part of traffic congestion resulting from an incident. Additionally, a method to encourage them to do is unknown. Research would need to determine a method for encouraging drivers to activate their hazard lights. It seems logical that many approaching drivers would experience enhanced awareness regarding the incident and its effect on traffic flow, but research is needed to substantiate this claim.

- Drivers that are fully aware that an incident is causing congestion continue driving without rerouting, leading to increased travel time. There are some concepts related to bounded rationality (e.g., choices that satisfy rather than optimize travel, decision thresholds, etc.) that could be used to generate decision making models for drivers approaching a traffic incident. For instance, there are computational models that predict why drivers will only alter their route after a travel-time changes in a way that surpasses their own individual-situation-specific threshold of travel time value [27]. The first step in this research would be to develop a model for driver decision making when approaching a traffic incident. Additional steps would require empirical support that could be obtained using survey methods, which is typical for computationally modeling driver decision making. But laboratory, simulator experimentation, or naturalistic data would likely provide more valid model parameters. Data from the recent SHRP2 naturalistic driving study and data from Battelle's motivations for speeding study, which consisted of large samples of people driving their regular routes, could feasibly be used to uncover factors related to route change. Such route change decision factors could be included in models for driver decisions when encountering traffic incidents.

- Traffic control devices for minor incidents could be evaluated in the real-world using qualitative methods and current state services, namely the roving incident response vehicles could serve as data probes. TMCs collect an enormous amount of information on minor traffic incidents that are serviced by roving incident responders. Incident response technicians are required to log specific details about the incidents that they service (e.g., type of incident, time it occurred, duration of service, location, etc.). Incident response technicians could easily log the types of TCD they use and the messages, but an additional device would be required to measure and record effectiveness (e.g., data logging cameras mounted on responder vehicles towards traffic). Incident response technicians may be better suited to assess the effectiveness of TCDs because they are more likely to be located upstream of the incident whereas other responders (e.g., fire and police) are at the location of the incident. Thus given the proper incentives, it seems very probably that incident response technicians could serve as viable measurement probes for observing and recording the benefits of TCDs installed at incidents.

# APPENDIX A: LITERATURE REVIEWS

**Table A-1. Literature reviews.**

| Reference | Findings |
|---|---|
| Ben-Bassat, T., and Shinar, D. (2006). Ergonomic guidelines for traffic sign design increase sign comprehension. *Human Factors, 48*(1), 182-195. | **Methodology:** For this survey study participants responded to local and non-local traffic signs and were required to write out the meaning of each sign in their own words. They also rated the signs on the extent the sign complied with the following ergonomic principles: spatial compatibility, conceptual compatibility, physical representation, familiarity and standardization.<br>**Findings**<br>▪ There was a moderate but significant correlation (r = .4) between the number of years driving and general comprehension.<br>▪ Of the 5 ergonomic principles there were 3 that had significant and positive correlations with comprehension: Compatibility (r = .76), Familiarity (r = .89), and Standardization (r = .88).<br>There was no difference in Compatibility ratings for local versus non-local signs, but local signs were rated as more familiar and more standardized than non-local signs. |

| Reference | Findings |
|---|---|
| Conference of European Directors of Roads (CEDR). (2011). *Best practice in European traffic incident management*. Retrieved from the CEDR website at http://www.cedr.fr/home/fileadmin/user_upload/Publications/2012/e_Incident_Management.pdf | **Relevant Practice**: TIM practices are highlighted for multiple European countries. Scene management involves preventing the escalation of the primary incident and the occurrence of secondary incidents; minimizing the disruption and congestion of traffic and, ensuring that there is a managed handover of the scene. A few notable aspects are:<br>▪ The use of *Incident Screens* has been found to reduce driver slowdown due to gawking or rubbernecking.<br>▪ The escort of contractors to incident scenes requires traffic control capabilities of the police – *no specific methods are mentioned*.<br>▪ Vehicles involved in the incident or passersby may be required or asked to use their vehicle hazard lights to increase awareness of the incident – *no specific rules or regulations are mentioned*.<br>Relevant techniques that require traffic control:<br>▪ *Rolling back/Convoy control* – "traffic-free windows" of specific length are created in by placing a responder downstream with a stop-sign to stop that is used to release traffic for specific intervals.<br>▪ *Hard Shoulder Running*: using the shoulder as a lane for traffic.<br>▪ *Rearward Relief*: allow trapped motorists to turn around and go the "wrong" direction down the highway toward a junction where they can reroute.<br>***Note***: Although congestion relief is not recognized as a goal of incident management by most European countries it is commonly recognized that it is the persistence of resultant traffic queues that can also contribute to secondary incidents, which are at higher risk to occur until the road section returns to normalcy. |

| Reference | Findings |
|---|---|
| Delcan and Georgia Department of Transportation (GDOT). (2011).*Georgia traffic incident management (TIM) guidelines*. Retrieved from http://www.timetaskforce.com/time-initiatives/tim-guidelines | **Practice:** There are two key components of incident management: (1) *Roadway clearance* which is accomplished when all travel lanes are open; and (2) *Incident clearance* which is accomplished when the last responder has left the incident scene. The duration of each can be used as assessment metrics. This document describes many of the personnel that respond to traffic incidents and how their efforts influence roadway and incident clearance. Personnel relevant to traffic control and their roles are listed below:<br>▪ *Law Enforcement:* officers play a major role in all of the traffic management processes, including: detection, notification, response, roadway clearance, incident clearance and after incident review meetings. Officers may remain on the scene until the recovery process is fully complete.<br>▪ *Crash investigators:* investigators are needed for crashes with serious injury or fatalities. Their work to safeguard evidence may lead to modifications of the TIM area.<br>▪ *Fire and Rescue:* can be responsible for establishing a safe transition area and incident work zone by using vehicle blocking techniques and traffic cones and TTC.<br>▪ *Emergency Medical Services:* EMS transport vehicles should never be used as a barrier vehicle for traffic control and are parked down-stream from the incident area.<br>▪ *Transportation Management Center:* coordinates incident activities using traffic cameras, updates changeable message signs and 511 alerts, can serve to coordinate incident management plans and estimate clearance time.<br>▪ *Towing and recovery:* If first to arrive should conduct scene survey and immediately set up traffic control for buffer and transition zones.<br>**Notable Procedures:**<br>▪ TIMA and TCDs should be used for crashes that do and do not block lanes.<br>▪ Positive Traffic Control is the use of stop/slow paddles, which are easier to understand compared to red flags.<br>▪ The responding agency is responsible for assessing and soliciting the required resources for deploying TTC.<br>▪ Special attention is paid to the end of the traffic queue to inform approaching motorists of slow or stopped forward traffic. |

| Reference | Findings |
|---|---|
| Hawkins, G., Conrad, J., Helman, D., …Tibbits, L., & Zeziski, M. (February, 2006). *Traffic incident response practices in Europe.* (Report No. FHWA-PL-06-002). McLean, VA: Federal Highway Administration. Retrieved from http://international.fhwa.dot.gov/tir_eu06/ | **Method**: Interviews were conducted with incident response specialists from England, Germany, the Netherlands and Sweden. The results were used to illustrate traffic incident management in Europe. Their use of TCDs and their policy are described below:<br>TCDs<br>▪ An *End of queue advance warning* is often deployed for incidents on high speed roadways. The queue warning informs upstream road uses who are approaching slower traffic. The cue warning is mobile, attached to a vehicle, and delivered using a sign that says "Stau (Backup or traffic jam)".<br>▪ Variable speed limits are used to reduce the speed of upstream traffic.<br>▪ Changeable message signs on the back of a vehicle can display a variety of messages to approaching traffic.<br>Policy Lessons Learned<br>▪ Unlike in the United States where several police agencies may have jurisdiction at the site of an incident there is only one local or regional police agency with jurisdiction at a particular incident.<br>▪ Private-sector auto groups function to patrol and provide roadside assistance to broken down vehicles – auto group membership is much higher in Europe than in the United States.<br>▪ Safety priorities – safety policy may be slightly different by region as shown below.<br>o England: 1) Safety escalation; 2) Establish Cordon; 3) Protect Scene and those working there; 4) Organize temporary traffic management with HA support<br>o The Netherlands: 1) Responder Safety; 2) Traffic Safety; 3) Assistance to Victims; 4) Maintaining flow; 5) Salvaging cargo/vehicle. |

| Reference | Findings |
|---|---|
| Kamyab, A., Maze, T. H., Gent, S., and Poole, C. (2000). Evaluation of speed reduction techniques at work zones. *Mid-continent Transportation Symposium 2000 Proceedings*, 189-192. | The authors evaluated three work zone speed reduction systems: a CB-Radio alert broadcast, a Safety Warning system alert, and a Speed Display Monitor.<br>**Function:** Control heavy-vehicle traffic through work zones.<br>Implementation of the three systems:<br>1. *The CB radio alert broadcast*: every 30 seconds it delivered very detailed advanced warning messages of upcoming delays at construction sites or incidents and this was effective for traffic control.<br>2. *The Safety Warning system alert*: consisted of a transmitter that would be detected by common radar detectors to give approaching drivers a sense that law enforcement was present – this was reported to be not effective. |

| Reference | Findings |
|---|---|
| McCormack, S. M., Walton, J. R., & Agent, K.R. (June, 2011). *Evaluation of Pilot Project: Emergency Traffic Control for Responders*. (Report No. KTC-11-05/SPR398-10-1F). Frankfort: Kentucky Transportation Cabinet. | This paper summarizes the results of a pilot project where 33 KY fire departments were provided with emergency traffic control (ETC) kits to determine if the equipment was sufficient and beneficial to responders.<br>**Method**: Participants received an ETC kit and a 4 hour training course. *Note:* typically emergency responders other than police officers are not provided training in traffic control. The training materials that were used had been publically available with only modest means of distribution.<br>ETC kits were based on MUTCD Kits were designed to be a minimal requirement for setting up traffic control, have low space requirements for storage on the fire trucks.<br>ETC kits included: Ten (10) safety vests, two (2) flagger stop/slow paddles, eighteen (18) traffic cones; six (6) fluorescent pink advanced warning signs (two "Emergency Scene Ahead", two "Be Prepared to Stop" and two flagger symbol) – these signs were flexible roll-up fabric packaged with their mounting bracket in bags..<br>**Findings:**<br>▪ Critical issues with departments deploying ETC: lack of man-power to deploy equipment; limited time to deploy equipment: limited storage spaced, lack of pre-existing procedures for routine usage.<br>▪ Responders did not feel the ETC kits corresponded to increased *time-on-scene* and continued requesting additional assistance with traffic control.<br>▪ Space issues for storing the ETC kits were addressed by: Storing kits on the top of the truck, removing other equipment to make space, reorganizing the truck, separating-out the kit and storing pieces at different locations on the truck, storing the full kit on a different truck that was called out to the scene if traffic control was needed.<br>▪ The most commonly used TCDs were: 1) Emergency vehicle flashing lights; 2) traffic cones; and, 3) advanced warning signs. Flaggers and stop/slow paddles were rarely used.<br>▪ 75% of departments carried paddles, cones and vests on the first responder vehicle and the advanced warning signs on the second responding vehicle.<br>▪ Signs were viewed as more beneficial on rural roads because there are no barriers on county roads to impede deploying signs, traffic is less likely to queue up, and topography (e.g. hills and curves) creates a need for advanced warning; also, interstate calls are infrequent. |

| Reference | Findings |
|---|---|
| Kimley-Horn of Michigan, Inc., Cambridge Systematics, and James B. Bolger & Associates. (2012). *Research findings and manual: Best practices for emergency rerouting*. (Report No. OR10-026). Retrieved from http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1581_401400_7.pdf | This document summarizes the best practices of rerouting traffic for emergencies. Most states have a centralized method for maintaining and storing their traffic rerouting data, which is typically stored digitally (e.g., a database of what routes were successful). Urban, suburban and rural areas require different considerations. For instance, urban centers support a larger number of alternative routes due to the typical grid structure. Also, physical characteristics of intersections need to be taken into consideration as the roadways need to support the rerouted traffic volume. Rerouting requires a significant quantity of personnel to accomplish. The following guidelines are provided:<br>▪ If the incident takes less than 30 minutes, do not reroute traffic<br>▪ If over an hour, law enforcement and MDOT may reroute<br>▪ If greater than four hours motorists will be rerouted on highway trunk lines.<br>▪ TTC signs (orange with black typeface) should be covered when not in use<br>▪ Short-term Traffic control signs (fluorescent pink) should be removed after use. |
| Ng, A. W. Y., and Chan, A. H. S. (2007). The guessability of traffic signs: Effects of prospective-user factors and sign design features. *Accident Analysis and Prevention, 39*(6), 1245-1257. | **Methodology:** This survey study investigated the relationship between the characteristics road signs and how well ratings of the following dimensions corresponded to enhanced comprehension: Familiarity, Concreteness, Simplicity, Meaningfulness, and Semantic closeness.<br>**Findings:**<br>▪ Semantic closeness explained 54% of the variance in how well participants understood the signs (Note: this is an adjusted variance that accounts for a collinearity confound for the semantic closeness dimension).<br>▪ Familiarity was highly correlation with comprehension (unadjusted $r^2 = .42$), Concreteness and Meaningfulness were moderately correlated ($r^2 = .39$, and .40), and Simplicity had a low correlation ($r^2 = .19$). |

| Reference | Findings |
|---|---|
| Shinar, D., Dewar, R. E., Summala, H., and Zakowska, L. (2003). Traffic sign symbol comprehension: A cross-cultural study. *Ergonomics, 46*(15), 1549-1565. | **Methodology:** This was a cross-cultural study comparative study that was done to asses sign comprehension across driver groups from four countries (Canada, Finland, Israel and Poland) using signs that were common as well as unique to the countries. There were 1,000 participants who were divided into 5 groups: novice, older, and problem drivers; tourists and university students. The task for participants was to describe the meaning of each sign in their own words.<br>**Findings:**<br>▪ Half (58%) of all responses to signs were fully correct and there were highly significant differences in comprehension among the groups of drivers within the countries.<br>▪ There was an effect of country, and group, as well as a complex interaction between country and group.<br>▪ Older drivers tended to exhibit lower comprehension overall.<br>▪ *Local signs*: Participants from Finland and Poland showed higher comprehension for local signs (80-95% comprehended perfectly) than Israel (65%-80% comprehended perfectly) and Canada (58%-68%).<br>▪ *Non-local signs*: Participants from Poland showed the highest comprehension for non-local signs (41-45% comprehended perfectly), Finland and Israel were lower (15%-41%) and Canada was the lowest (8%-20%). |
| Wiles, P. B., Cooner, C. G., Walters, C. H., and Pultorak, E. J. (June, 2003). *Advance warning of stopped traffic on freeways: current practices and field studies of queue propagation speeds* (Report No. FHWA/TX-03/4413-1). Austin: Texas Department of Transportation. | **Methodology:** Observational field research was carried out at various locations with traffic stopped as a result of various congestion conditions in order to determine proper advance warning techniques.<br>**Findings:** There were instances of rapid fluctuation of queue length and duration. TCDs placed too near or far from a traffic cue results in drivers 'overrunning' the sign and disregarding it because it is interpreted as inaccurate if the queue is not visible. Conditions were shown to change too rapidly for human operators to make sign adjustments in real-time. |

| Reference | Findings |
|---|---|
| WisDOT. (February, 2012). *Emergency traffic control and scene management guidelines (Version 2.0).* Retrieved from http://www.dot.wisconsin.gov/travel/stoc/docs/emer-tc-sm-guidelines.pdf | This document provides guidelines for traffic control and scene management for traffic incidents. The guidance on initial activities and TTC are described. Incident management practice must support quick restoration to normalcy while preserving the scene until evidence has been obtained<br>***Initial Activities***: The most important initial activities for incident management is communicating the specifics about the scene (i.e., *Scene Size-up*). These specifics include: information on the incident location, details on vehicles and injured persons, incident classification, if the incident is on a state or county facility, scene conditions (e.g., smoke from vehicles, weather, etc.), traffic conditions (e.g., the length of any traffic queues), etc.<br>There are three *Incident Classifications* as per MUTCD that are based on the expected incident duration:<br>▪ *Major* – More than 2 hours<br>▪ *Intermediate* – 30 minutes to 2 hours<br>▪ *Minor* – Less than 30 minutes<br>***TTC***: The primary functions of TCDs at incidents are to inform road users of the incident and to provide guidance information on the path to follow through the incident area. Accordingly, A TIMA consists of 4 main components:<br>1. *Advanced warning area* – used to warn motorist of the upcoming incident scene and promote a reduction in travel speed. Emergency vehicle lighting functions only to warn drivers and provides no effective traffic control. Emergency vehicle lighting can be reduced after a TIM area has been established to reduce glare issues for on-coming drivers<br>2. *Transition area* – where drivers are redirected out of the normal path.<br>3. *Activity area* – area where the incident activities take place. It includes a buffer space and the incident space. Larger vehicles like fire trucks can be used to block the incident zone when placed in the buffer zone at an appropriate angle<br>4. *Termination area* – an area used to notify traffic that the incident management area is ending and they may resume normal driving. Flaggers can be placed upstream to indicate to provide stop/go/slow traffic control.<br>Incident scene breakdown should occur in a backwards manner starting from the termination area and ending at the advance warning area. |

| Reference | Findings |
|---|---|
| WSDOT Incident Response Program: Strategic Plan For Traffic Incident Management. Last accessed 10/23/2013 http://www.wsdot.wa.gov/NR/rdonlyres/B79A29B1-2F56-43CA-BBC0-AFB25FACE209/0/IRSStrategicPlan.pdf | This document outlines WSDOT traffic incident management practice, strategic partnerships and established programs. One notable practice aspect is the requirement for longer term incidents (e.g., those that block traffic lanes for more than 60 minutes) to abide by an MUTCD work-zone guidance to establish traffic control, otherwise there is substantial overlap with other incident management guidelines documents.<br>**Partnerships:** An agreement between WSDOT and the Washington State Patrol was established for data sharing, traffic management, work-zone safety, commercial vehicle operations. The agreement shares a mutual goal of clearing highway traffic incidents within 90 minutes, which requires additional partnerships with fire and EMS services towing, the media, and the insurance industry.<br>**Programs:** There are many programs that are discussed within this planning document, some notable programs are below:<br>▪ *Instant Tow Dispatch Protocol*: When this protocol is activated a tow, trooper and incident response technician are dispatched immediately to the scene, eliminating the verification process. This is a time saving measure that presumably results in sizable societal costs savings per incident, upward $35k.<br>▪ *Liability protection for those acting on behalf of the scene Officers and DOT representatives*: In order to clear scenes quickly liability protection is provided to anyone acting under the direction of the officer on the scene or the DOT. This helps to alleviate towing and recovering vender concerns about liability for damage to vehicles or cargo when clearing traffic scenes.<br>▪ *Roving Incident response technicians*: These are specially trained personnel who primarily focus on incident detection and clearance. These roving technicians patrol areas that are typically congested and respond to incidents that disrupt the flow of traffic (e.g., clearing stalled vehicles, jump starting, etc.) but they also provide traffic control support for major traffic incidents and assist incident commanders with general scene management. Technicians who travel and work alone have to choose between assisting at the scene or managing traffic, pairs of technicians can accomplish both. |

# APPENDIX B: SME INTERVIEW TEXT BODY FOR RECRUITMENT EMAIL LETTER

The ***Federal Highway Administration*** (FHWA) is conducting a project to identify versatile temporary traffic signs that can be used by first responders at traffic incidents. In order to better understand how temporary traffic signs are used for traffic incident management we are conducting interviews with practitioners who respond to and/or manage traffic incidents.

This topic was identified by the FHWA Traffic Control Devices Transportation Pooled Fund (TCD-TPF) Consortium. The results of these interviews will be used to develop additional studies to evaluate how well drivers comprehend current temporary TCDs used in the US and abroad, and of any novel temporary traffic sign designs that come from this project. The signs identified in this project will be considered for inclusion in the Manual on Uniform Traffic Control Devices (MUTCD).

Interviews are expected to be 30 to 45 minutes in duration. Our availability to conduct interviews is shown in Table 1 on the next page. General interview topics are listed below.

**Interview topics:**

- Types of incidents that require temporary Traffic Control Devices.
- Traffic Control Devices used and their usefulness.
- Guidelines on temporary Traffic Control Devices and their use.

*Note*: These interviews will be casual and confidential. If you choose to participate your responses to our questions will never be connected with information that would identify you.

## APPENDIX C: SME INTERVIEW MODERATOR GUIDE

# Warning Sign Legends for Emergency Incidents (TO12 Warning Sign Legends): Moderator Guide

There will be three steps to each interview. As outlined below the first step will be to greet the participant, the second step is to introduce the discussion topic and purpose of the interview and the third step will be to carry-out a general discussion guided by basic questions about current practices. The anticipated duration of each interview is approximately 45 minutes. The step with the longest duration will be this third step.

**Greet Participant (1-2 minutes)**

Greet and indicate our request to record their voice and their right to refuse this request.

> "*Thanks for joining. We would like to interview you about your expertise on traffic incident management. To facilitate our note-taking and to improve data accuracy, we would like to make an audio recording of the interview. This helps the interview move more quickly, but it is not something we require. We will ask for your permission before we record anything, and after we have transcribed the recording/confirmed our notes, the recording will be destroyed. If you would prefer to not be recorded, please let me know and we will certainly accommodate that preference*"

*Note*—No additional personal identifying information will be asked during interviews. Name and email will only be used for scheduling interviews.

**Introduction to topic and purpose of interview (1-2 minutes)**

"Our objective is to obtain information on the use of temporary traffic control devices used for traffic incidents like vehicle crashes on the freeway. We want to hear about problems that are encountered when setting up a traffic incident management area and ways of dealing with these problems. The results of these interviews will be used to provide information to sign designers about options for traffic control device messages"

**High-level Discussion topics (25 to 45 minutes)**

Our goal is to obtain novel information regarding traffic incident management, specifically in regards to how experts use incident signs. Currently there is no information on this topic. However, information is available on general traffic incident management. This general information informed our current moderator guide. Initial interviews will cover the high level topics listed below. Each topic listed below contains the initial question we will ask interviewees about the topic.

- Topic: Traffic incidents encountered:

"*Can you describe the types of incidents that require temporary traffic control devices? For example, can you tell us about setting up traffic control devices for an incident classified as a Major Incident?"*

- Topic: Traffic Control Devices Used:

  "*Can you describe the types of temporary traffic control devices that are used for the incidents mentioned previously? Are any of the signs used for multiple incident types? For example, some responders deploy a sign that simply states Emergency Scene Ahead for the incidents they respond to…"*

- Topic: Effectiveness of traffic devices:

  "*Considering the temporary traffic control devices that were mentioned already or other devices that are used for traffic incident management, can you provide insight on their general effectiveness. For instance, are there signs that are effective for use in more than one incident or is it important to use signs that provide drivers with situation specific information, for example, the use of temporary traffic devices for hazardous material spills are sometimes specific and state, Hazardous Material Spill Ahead"*

- Topic: Current practices and available documentation of current practices:
  *"Are there documents that serve to guide the deployment of temporary traffic control devices at traffic incidents? Can you describe them and how they're used? We are also interested in learning as much as we can about actual practice, for instance what happens in the field in terms of how guidelines and training are deployed*

# APPENDIX D: FOCUS GROUPS INSTITUTIONAL REVIEW BOARD NOTICE

**Battelle Corporate Operations**
**505 King Avenue**
**Columbus, Ohio 43201**
**Federalwide Assurance FWA0004696**
**Battelle IRB – BCO Line of Review No. IRB00000284**

**IRB 0513, Rev 1.0**
**Notice of Exemption from Federal Regulations for the Protection of Human Subjects Form**

**NOTE**: Exemption from federal regulations for protection of human subjects DOES NOT mean that the research study is exempt from Institutional Review Board (IRB) requirements or oversight. The IRB will identify any specific requirements and may require periodic status updates.

**Principal Investigator/ Project Manager:** Justin S. Graving

**Project Title:** Warning Signs Legends for Emergency Incidents

**Client/Funding Agency:** Federal Highway Administration

**IRB No:** 0513, Rev 1.0 **Date of Submission to IRB:** April 4, 2014

**Proposal No:** OPP112651 **Project No:** 100036877

**Contract to Battelle from:** N/A

**Subcontract from Battelle to:** N/A

**Level of IRB Review:** **Exemption from Regulation**

Meets criteria for classification as Human Subjects Research. Meets criteria for Exemption per 45 CFR 46.101(b)(2), *Interview or survey of adult subjects, **unless** information is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects AND disclosure of the human subjects' responses outside the research reasonably places the human subjects at risk or is otherwise damaging to the human subjects' financial standing, employability, or reputation.*

Minimal risk to adult participants who are professional incident responders and members of the general public. Prospective responders will be recruited via focused informational flyers and/or social media; public members will be recruited through Craigslist. Interaction requires participation in moderated focus groups. Focus group(s) will be video-recorded for transcription and quality assurance purposes only; recordings will be destroyed upon transcription. Persons who do not verbally consent to video-recording will not be allowed to participate. Age, gender, and occupation/job title will be collected to assess make-up of focus group(s), but data confidentiality measures are adequate and all human subjects' responses will be reported in aggregate or as anonymous quotes. Participants will be compensated for their participation. Participation is entirely voluntary; there is no indication of coercion or undue influence. Documented informed consent is not required, but prospective participants will be provided a written "Study Briefing" that describes the purposes, risks and benefits of the study.

Any proposed changes to the testing plan or future phases of this research involving interaction with prospective participants must first be evaluated by the Battelle IRB.

**Changes in Protocol.** If amendments to study protocol or documents for IRB 0513, Rev 1.0 are anticipated, notify Gary Sapp, 614-424-7648, Room A-2-089, and submit the changes for review and approval before they are implemented.

| Reviewer, BCO Line of Review | Robert A. Lordo, Ph.D. | Robert A. Lordo | 4/8/2014 |
|---|---|---|---|
| Title | Name | Signature | Date |

Battelle Institutional Review Board (IRB)

# APPENDIX E: FOCUS GROUPS PARTICIPANT BRIEFING FORM

***This form describes the procedures of the research, what you will be expected to do as a participant, and other important information that you should consider before volunteering to participate in this research. Please read this form carefully and ask as many questions as you like before deciding whether you want to participate in this research study.***

## Purpose of the Research Study

You are being invited to participate in a focus group brainstorming session to help create new traffic control messages for traffic incidents. The purpose of this research is to help identify novel messages that could be used for traffic control during temporary traffic incidents. Traffic incidents are car crashes, weather events, or any other unplanned event that could affect traffic. As part of this research, we are conducting separate focus group sessions involving the general public and incident response professionals.

## Procedures

During the focus group, you will be asked to generate messages that you think would help drivers when approaching a traffic incident. You will be shown a variety of driving scenarios that represent traffic incidents and will be asked to either write down or talk about specific messages that you think would be helpful to drivers, and help responders control traffic. The focus group sessions will last approximately 60 to 90 minutes. During today's focus group, you will be asked to complete a brief questionnaire that asks about your demographic information and your driving experience. An experienced focus group moderator will be on hand to ensure that the discussions remain appropriate and on topic.

The potential risks associated with your participation in this focus group are minimal. These risks are the same as would normally be expected at a public meeting involving discussions among participants. There is risk of involuntary disclosure by other people who participate in this focus group. The researchers are obligated to maintain your confidentiality and will never in anyway disclose information about you. You are in control of your confidentiality, and the confidentiality of the others in the focus group. After the focus group, please respect the confidentiality of others and refrain from discussing anything that might identify other participants as having participated in this focus group.

The results of these focus groups will help to influence guidelines and standards committees' decisions on what messages to recommend or make mandatory. Such efforts may improve traffic flow and save lives by reducing the number of secondary crashes that occur at traffic incidents.

You will receive $75 for your participation today.

**Confidentiality**

Please be aware that the focus group session will be videotaped for data analysis and quality assurance purposes. You will not be asked to provide any identifying information beyond your first name. The identifying information collected for recruitment purposes will be kept private and will not be linked with any information collected during the focus group session. The results of this focus group may be published in a technical report or academic journal. Your name or any identifiable references to you will not be included in any published documentation. In order to protect your confidentiality, all identifying information and videotape recordings will be kept in locked cabinets during the research project. Only research staff from the research contractor, Battelle, will have access to information and videotape recordings from this focus group. Upon completion of the study, all identifying information and videotape recordings will be destroyed.

Any records or data obtained as a result of your participation in this study may be inspected by the sponsor, by any relevant government agency, by the Battelle Institutional Review Board, or by the persons conducting this study, provided that such inspectors are legally obligated to protect any identifiable information from public disclosure, except as otherwise required by law. These records will be kept private in so far as permitted by law.

**Termination of the Research Study**

You are free to choose whether or not to participate in this focus group. If you choose not to participate, you will not be penalized or lose any benefits to which you are otherwise entitled. You are also free to stop participating in this focus group at any time.

**Available Sources of Information**

Mr. Justin Graving, the principal investigator, is available to answer any questions you have about this focus group. Mr. Graving can be reached at (206) 528-3268. Also, the administrative manager of the Battelle Institutional Review Board will answer any questions you have about your rights as a research subject. The administrative manager can be reached by calling (614) 424-7648.

# APPENDIX F: FOCUS GROUPS RECRUITMENT ADVERTISEMENT

**Participants Needed for Focus Groups on Driving Safety**

Battelle, a nonprofit research organization, is seeking participants for focus groups discussing traffic warning signs for emergency incidents.

Requirements:

- Age 18 or over
- Licensed driver
- Drive at least 3 – 4 times a week
- Willing to share thoughts and opinions in a group setting

*Three sessions will be held in the South Lake Union area of Seattle:*
*Tues, April 22 at 10 a.m. / Wed, April 23 at 2 p.m. / Mon, April 28 at 2:30 p.m.*

Parking will be validated

Compensation: $75 cash for 1.5 hours

If you are interested in participating, please email DrivingStudybattelle.org with the following information:

1. Name
2. Age
3. Gender
4. Telephone number
5. Date/time of session(s) that you are available

Please note that our return phone calls to you will show as "Unknown Caller" on mobile phones.

Thank you!

**APPENDIX G: FOCUS GROUP MODERATOR GUIDE**

# Warning Sign Legends for Emergency Incidents (TO12 Warning Sign Legends): Moderator's Guide for Focus Groups

This Moderator's Guide serves as a framework to help the moderator generally cover the topics of interest. However, given that this is a moderated discussion, these questions should be considered to be more as "touch points" rather than fixed topics. The moderator will follow up on related topics opportunistically, with the objective of exploring issues related to the topics of interest.

**Consent and Participant Payment**

Provide participants the consent form. Allow them to read it. Ask if they have questions. Have them tell you what they are expected to do.

Pay each focus group attendee as they arrive. This will make it easier for them to leave at the end of the session or if they decide to discreetly drop-out of the focus group while it is on-going.

**Greeting & introduction [5 minutes]**

1. GREET FOCUS GROUP

   *"I am the moderator for today's discussion. We will be here for about an hour and the purpose of today's focus group is to talk about messages or legends that are used for Traffic Incident Management to control traffic and inform drivers of an incident they are approaching. Specifically we are interested in novel ideas for messages."*

2. DISCLOSURES

   *"I work for a research company called Battelle Memorial Institute.*

   *My job is to report novel message ideas back to my client, Federal Highway Administration (FHWA) of the US Department of Transportation. I have no vested interest in your answers and my job will continue regardless of what is said here today. I encourage you to be honest and feel free to offer both positive and negative comments.*

   *This session is being videotaped. A record of today's information will help immensely for evaluating the ideas that are set forth by this group. Evaluation of the content in the recording will be carried out at a later date. The recording will be kept confidential, not be shared with anyone, and will be destroyed after the*

*evaluation is complete. Names, personal identifying information and any likeness of yourself will be purposefully excluded from any reports or documents that are generated based on our discussions today."*

3. GROUND RULES FOR THE FOCUS GROUP

*"Before we get started, I'd like to go over some ground that may help you get an idea about how this focus group will work.* There are some ground rules we need to follow*.*

1. Write down your message ideas in the response book before talking about them with the group.
2. Allow others who are speaking to complete what they are saying.
3. Keep in mind that we are brainstorming as a group and that all opinions are valuable. To encourage 'outside of the box' thinking, please consider that any current practices you may be aware of do not apply. Imagine that there are no authorities on the topic that are present in group, including.
4. Contribute to the discussion. There may be times when you are the only person in the group that feels a particular way. Please speak up when this occurs.

Are there any questions?"

4. OVERVIEW OF TABLETOP ACTIVITY AND RESPONSE BOOKLET.

*"The purpose of the focus group is to brainstorm novel messages for traffic incidents like car crashes. The large image on the table will help us to think about all the factors associated with traffic incidents. Incidents will be set-up using these miniature vehicles. We will work through about a dozen incidents and will use a response booklet to guide this process. For each incident I want you to write down sign message ideas, where the sign messages would be located and what the intent or meaning of the message (i.e., what are you trying to communicate to approaching motorists).I will be asking questions throughout the focus group today. We will also place post-it note versions of your messages on the image and have some general discussion about how these novel messages may facilitate drivers and responders.*

5. CONDUCT TABLE TOP ACTIVITY

Refer to scenario guide (in-development)

**Focus Group Questions:** The questions below will be asked throughout the brainstorming session.

6. DISCUSSION ON GENERAL SIGNING

*"Let's talk about the types the use of a specific message for multiple incidents. For example, how useful is the message EMERGENCY SCENE AHEAD at several types of incidents (e.g., vehicle crashes, fire, hazmat spills, etc.) as opposed to specific messages (e.g., ACCIDENT AHEAD, FIRE, etc.)?*

*"There appears to be a need for effective general messages as responders often use a small set of messages on static signs or on portable VMS…."*

7. BRAINSTORM NOVEL MESSAGES

*"There are constraints regarding how messages are presented. Here are the constraints we will work with for our session:*

If the message is presented on a Variable Message sign

*"Let's now work together to generate novel ideas for generalizable signs that would work across multiple incidents*. [Discussion topics that will be incorporated into the moderation for brainstorming are below]:

7.1. QUESTIONS ABOUT ANY MESSAGES THE PARTICIPANTS GENERATE

"*Do you know if this message is already in use?"*

*"Using words other than those that are in the message, what is this message telling drivers?"*

*"Does this message increase driver attentiveness? Is it possible to create a specific messages causes drivers to be more attentive?"*

7.2. QUESTIONS ABOUT MESSAGES TO ENHANCE DRIVER RISK PERCEPTION

*"If drivers need to know the driving risks associated with an incident, do you think general messages influence how drivers' perceive their own risk when approaching an incident they are approaching?*

*To enhance how well drivers understand the risk of an incident, should messages for vehicle crashes, hazmat spills, flooding, etc. be different?*

*What are some ideas for messages to increase driver awareness of the risks associated with the incident?*

*Consider the risks associated with disregarding traffic control, should these risks be clearly stated in messages to drivers?"*

## 7.3. ADDITIONAL QUESTIONING ASKED THROUGHOUT THE BRAINSTORIMING PORTION OF THE SESSION

*"General messaging might allow incident responders to do their job more effectively as they wouldn't have to sort through a larger set of messages. General messaging may also allow the general public to become more familiar with the messages that are used and get a better sense for their meaning.*

*Are there other practical advantages for both drivers and responders regarding the use of consistent messaging across different types of traffic control situations?*

*Sometimes the same message appears on a static sign and on an electronic variable message sign within the same scene. Does providing redundant messages in different modalities like this increase the likelihood drivers receive a message?*

*How many messages are appropriate and what should they say (e.g., a text message that says 'emergency ahead' and a guide sign telling drivers to merge)?*

*What messages or types of messages can be repeated in a driving scene that would be beneficial for approaching an incident on a roadway?*

*There are three classifications for incidents, 1) Major, which lasts for two or more hours; 2) intermediate, which lasts for 30 minutes to two hours; and, 3) minor, which is an incident less than 30 minutes). The most common incidents are minor incidents and typically there are no messages for these types of incidents. Yet, there are instances when a minor incident can be upgraded to intermediate or major. If you think there is value in sharing the incident classification with drivers in some manner, what messages would be useful for the different incident classifications?*

**APPENDIX H: FOCUS GROUPS RESPONSE BOOK**

# Example of Focus Group Response Book

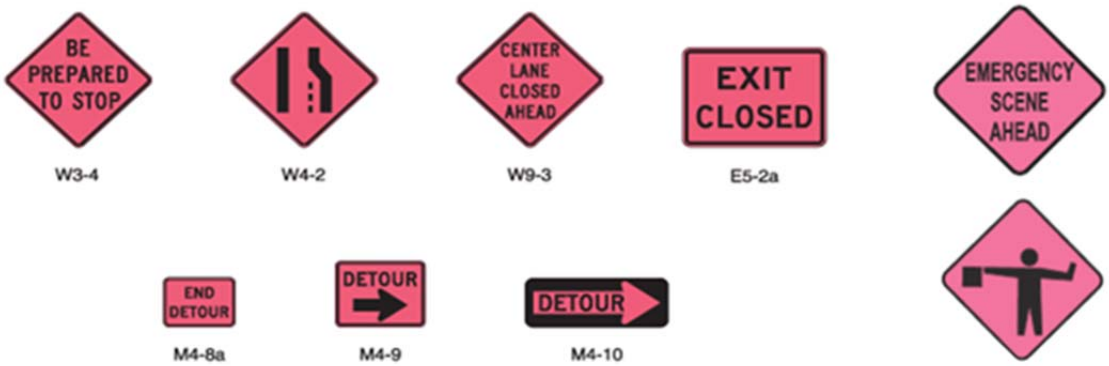
Topic: Messages to drivers approaching a traffic incident.

# Survey Questions

| | |
|---|---|
| **1. What is your age?** | |
| **2. What is your gender?** | |
| **3a. What is your current occupation/job title?** | |
| **3b. How many years have you been working in your current occupation?** | |
| **4. How many years have you been driving?** | |
| **4. Typically, how many days of the week do you drive?** | |

# Introduction

Example messages, and table top exercise instructions.



**Example messages Continued**

BE PREPARED TO STOP
BE READY TO STOP
CRASH 1 MILE AHEAD LEFT LANE CLOSED
CRASH 3 MILES AHEAD
DANGER
DO NOT PASS
EMERGENCY AHEAD
EMERGENCY SCENE AHEAD
FIRE SCENE AHEAD
INCIDENT AHEAD
LIVE WIRES/ELECTRICAL HAZARD
MERGE
ROAD CLOSED AHEAD
ROAD CLOSED LOCAL ONLY
RAMP CLOSED
SLOW
TRAFFIC CONGESTION AHEAD BE PREPARED TO STOP
TRAFFIC STOPPED AHEAD
WATCH FOR STOPPED TRAFFIC

**Tabletop Exercise Instructions**

The purpose of the focus group is to brainstorm novel messages for unplanned traffic incidents like car crashes. The images of roadways shown below will help us to think about all the factors associated with traffic incidents. Incidents will be set-up on larger versions of these images using miniature vehicles.

We will work through about several incidents and will use this response booklet to guide the process. For each incident, please write down sign message ideas, where the sign messages would be located and the intent or meaning of the message (i.e., what are you trying to communicate to approaching motorists). There is an example below.

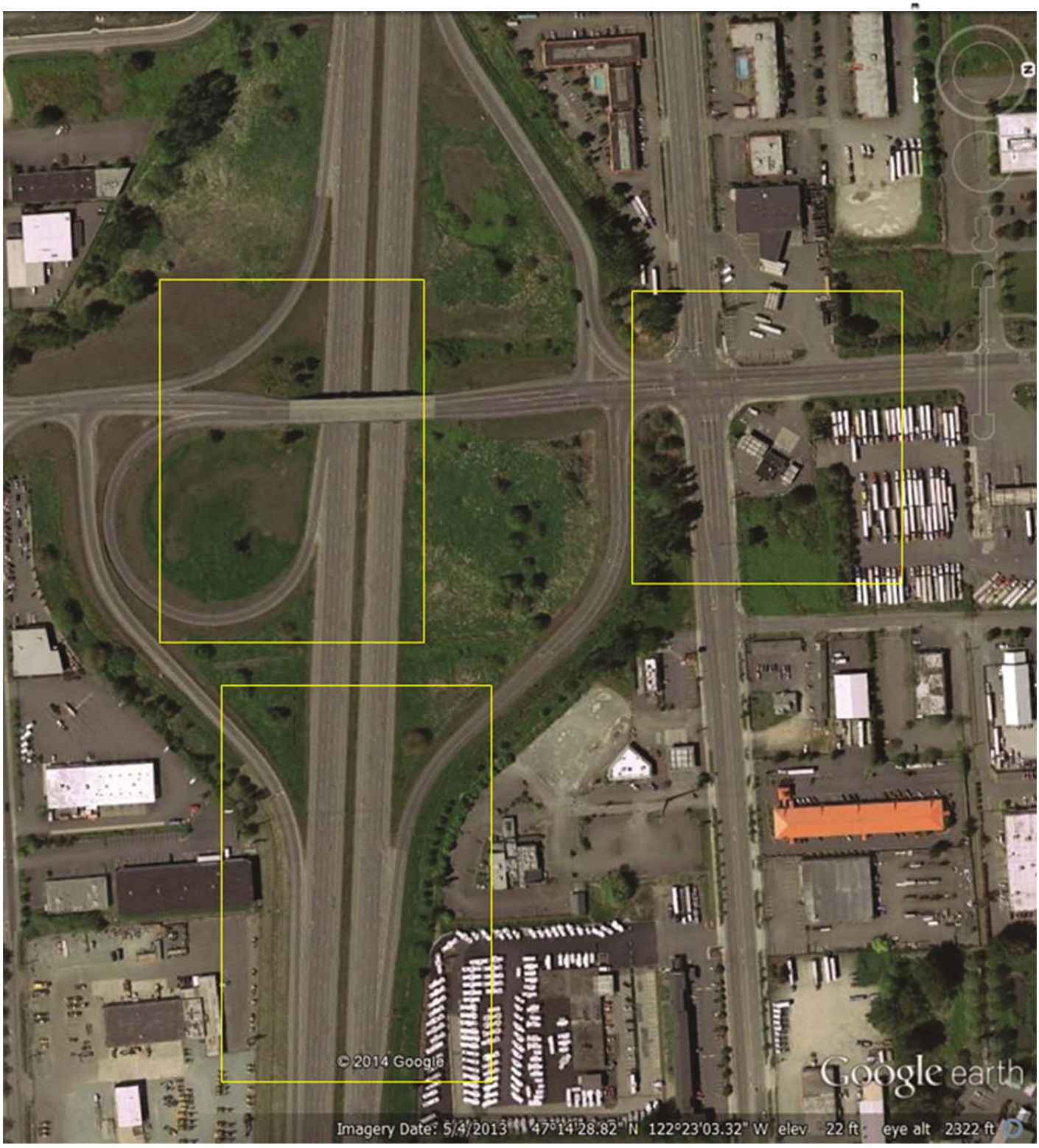
Post-it notes are available, and you are encouraged to write your message ideas and place them on the larger image. We will ask questions throughout the focus group today to encourage some general discussion about how these novel messages may facilitate drivers and responders.

**Example Response**

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| Emergency Scene Ahead | F-8 | To indicate there something happening on the road ahead, location allows for… |

*Note* — All incidents are made-up. To the best of our knowledge they do not truly represent incidents that have actually ocurred.

**Roadways — Yellow boxes represent locations of today's scenarios. This can serve as a reference to give perspective on the surrounding area.**



**Scenario 1: Partially blocked sharp curve freeway off-ramp during the peak hours of the day**

| | |
|---|---|
| • A grain truck tipped over and spun while exiting and is on its side.<br>• A large amount of grain is on the exit ramp.<br>• The grain is blocking the exit lane but the inner shoulder is clear. The shoulder is wide enough for people to drive on.<br>• Traffic volume is high and will back-up quickly.<br><br>*Provide advance warning, useful information and traffic control to both drivers passing by and using the exit ramp.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 2. There is a multi-car collision blocking most lanes**

| | |
|---|---|
| • A crash between multiple vehicles blocks the right shoulder and all driving lanes.<br>• The left shoulder remains unblocked.<br>• Traffic is heavy<br><br>*Provide advance warning, useful information and traffic control to all drivers.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 3. Middle lane collision during the peak hours of the day**

| | |
|---|---|
| • A severe two-car crash occurred in the middle lane of a three lane highway.<br>• The shoulders and the outside lanes are clear.<br>• Traffic volume is high and will back-up quickly.<br>*Provide advance warning, useful information and traffic control to both drivers passing by and those using the exit ramp.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 4. Immobilized truck in the median**

| | |
|---|---|
| • An immobilized jack-knifed truck is located in the median.<br>• Middle shoulder and both adjacent lanes are blocked.<br>• All other lanes are unblocked.<br>• Traffic volume is high and will back-up quickly.<br><br>*Provide advance warning, useful information and traffic control to both drivers passing by and those using the exit ramp.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 5. Shoulder collision between entering vehicle and mainline traffic**

| | |
|---|---|
| • A rear-end collision between a small car and a heavy-truck occurred when a driver merged too early into the mainline traffic when entering the highway.<br>• The shoulder and first adjacent lane are fully blocked.<br>• The entrance ramp is partially blocked but the far hard shoulder clear.<br><br>*Provide advance warning, useful information and traffic control to all drivers.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 6. Crash on the exit ramp due to a last minute exit during atypically high traffic**

| | |
|---|---|
| • There was a severe multi-vehicle crash in the exit ramp due to a driver's decision to exit at the last second.<br>• In addition, the Mazda plant is having a surprise car show that is now drawing a huge crowd from Seattle. The crash has already caused a traffic back-up.<br>• The exit ramp is completely blocked but all mainline lanes are clear.<br>*Provide advance warning, useful information and traffic control to all drivers.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 7. Middle intersection collision during the peak hours of the day**

| | |
|---|---|
| • A two-vehicle collision at a signalized 4-way intersection is blocking through traffic.<br>• Right-turn lanes are clear.<br>• Traffic volume is high and will back-up quickly.<br><br>*Provide advance warning, useful information and traffic control to both drivers passing by and those using the exit ramp.* | *Insert Satellite image* |

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

**Scenario 8. Pavement failure at a 4-way intersection**

- A pipe burst under the Port of Tacoma road and caused the pavement to collapse.
- Underground plumbing for a nearby business is suspected to have caused it.
- Southbound lanes are blocked, including through-lanes and, right and left turn lanes.

*Provide advance warning, useful information and traffic control to all drivers.*

*Insert Satellite image*

| Message | Location | Meaning—What are you indicating to drivers |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**Additional Comments:**

# APPENDIX I: FOCUS GROUP RESPONSE TABLE

**Table I-1. Focus group responses.**

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 1 | IR_1 | COLLISION<br>PORT OF TACOMA RAMP BLOCKED | VMS on the bridge at B1 | "Where is it, what is it and what do we want you to do because of it." | x | x | | | x |
| 1 | IR_1 | CRASH AHEAD<br>RAMP LANE CLOSED AHEAD | A mile up-stream from the incident | N/A | x | x | | | |
| 1 | IR_1 | Shift arrow sign to the right | C6 | Let drivers know that we need them to shift over to the shoulder, but are not moving them out of that lane. | | | | x | |
| 1 | IR_1 | Right pointing arrow | Behind the incident (PVMS on IR truck) | To move drivers onto the shoulder. | | | | x | |
| 1 | IR_1 | RAMP PARTIALLY CLOSED<br>SLOW<br>STOPPED TRAFFIC AHEAD | Upstream of A1 (Put second message on PVMS on a second IR truck) | To notify drivers to drive slowly | x | x | | | |
| 1 | IR_1 | RAMP SLOWED TO 10 MPH | C1 | To slow traffic entering the ramp | | x | | | |
| 1 | IR_1 | INCIDENT/CRASH AHEAD - RAMP ONLY | C1 | To tell drivers that "only the ramp is affected"<br>Attempt to prevent too much traffic from entering the ramp | x | | | | x |
| 2 | IR_1 | ALL LANES BLOCKED<br>NORTHBOUND I5<br>PORT OF TACOMA ROAD | B1 and upstream Posted at the closest 3 permanent VMS boards | Initial messaging | | x | x | | x |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 2 | IR_1 | ALL LANES BLOCKED<br>ALTERNATE ROUTE SUGGESTED | B1 and upstream | Initial messaging | | x | | x | |
| 2 | IR_1 | COLLISION<br>PORT OF TACOMA ROAD<br>LEFT LANE OPEN | B1 and upstream | Telling drivers that the shoulder is open but without saying that it is a shoulder. | x | | | x | x |
| 2 | IR_1 | CRASH AHEAD<br>3 LEFT LANES CLOSED AHEAD<br>Transition signs | A1 to B2 | Guide traffic onto the exit ramp away from the incident | x | x | | x | |
| 2 | IR_1 | MOVE TO FAST LANE | N/A | For incidents that block 2 lanes of a 3 lane roadway | | | | x | |
| 2 | IR_1 | MOVE ALL THE WAY LEFT | N/A | For incidents that block 2 lanes of a 3 lane roadway | | | | x | |
| 2 | IR_1 | MOVE OVER NOW | N/A | For incidents that block 3 lanes. | | | | x | |
| 2 | IR_1 | MOVE TO LANE 1 | N/A | For incidents that block 2 lanes of a 3 lane roadway | | | | x | |
| 2 | IR_1 | IMMEDIATE DETOUR | N/A | All lanes are blocked. | | | | x | |
| 2 | IR_1 | RIGHT LANE CLOSED on VMS<br>&<br>Arrow/chevron on PVMS | B2 for VMS and D2 for PVMS<br>This arrangement is highly probable if the PVMS operator knows that the VMS says RIGHT LANE CLOSED. | Provides information and the arrow shows drivers exactly what they need to do. The arrow/chevron is simpler. | | x | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 2 | IR_1 | NO RE-ROUTE THROUGH DUPONT | Upstream of incident | To help people who don't know their way through town that they won't be able to use that specific roadway to re-route.<br>Only the people that live in the area know that you can't get through the town, which is a small portion of our audience. | | | | x | |
| 2 | IR_1 | "I-5 Closed"<br>"XX minutes" | Upstream as far as possible | Send messages to truckers to help them exit in time. | | x | | | |
| 2 | IR_1 | INCIDENT AHEAD<br>HEAVY TRUCKS<br>NO REROUTE<br><br>Or<br><br>TRUCKER REROUTE TO CR 509 | Upstream as far as possible on VMS. | Send messages to truckers to help them exit in time. | x | | x | x | |
| 3 | IR_1 | COLLISION<br>CENTER LANE BLOCKED<br>PORT OF TACOMA ROAD | Upstream as far as possible | To inform drivers of the collision, that it's blocking the road and the nearest cross-road to the incident. | x | x | | | x |
| 3 | IR_1 | LEFT LANES CLOSED AHEAD | Upstream | That drivers need to use the lane farthest to the right. Bigger incident than just a single lane closure. | | x | | | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 3 | IR_1 | FIRE/POLICE ACTIVITY AHEAD | Upstream on the VMS. | After a crash has been cleared, but there is still additional cleanup required, in order to be informative and not deceptive, this message indicates a real reason for a traffic delay. HAZMAT SPILL would cause too much public to inquiry. | x | | | | |
| 3 | IR_1 | NO STOPPING | No specific location | To keep drivers from stopping on the highway to rubberneck or wait for an incident to clear. To avoid driving over spilled material drivers may wait it out on the shoulder, even if there is a passable lane. | | | | x | |
| 4 | IR_1 | COLLISION AHEAD LEFT or RIGHT LANE BLOCKED [CROSS-ROAD NAME] | Upstream VMS for both bounds of traffic | To inform drivers of the collision, that it's blocking the road and the nearest cross-road to the incident. | x | x | | | x |
| 7 | IR_1 | CRASH AHEAD | Back from every corner of intersection | To give an initial warning that something is going on | x | | | | |
| 7 | IR_1 | NO LEFT TURN | After Crash ahead sign | To tell drivers what is closed. | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 7 | IR_1 | RIGHT TURN ON RAMP CLOSED AHEAD (Won't use ramp closed because the ramp is not really closed) | On Freeway VMS | To prevent drivers from turning into the accident scene, and get them to go straight through or turn left. This message would be used if the responders decide to block traffic coming from the highway. | | | X | x | |
| 8 | IR_1 | RIGHT LANES CLOSED AHEAD, cones and a shift arrow | H3 | This arrangement tells drivers to use the on-coming lane. | | x | | | |
| 8 | IR_1 | LEFT LANE CLOSED AHEAD and a transition sign | A1 & B1 | To tell northbound traffic to merge to the right to allow for southbound drivers to use the inside oncoming traffic lane. | | x | | | |
| 1 | IR_2 | MERGE TO SHOULDER | Upstream of the incident | Drive on the shoulder | | | | x | |
| 1 | IR_2 | PROCEED ON SHOULDER | Upstream of the incident | Drive on the shoulder | | | | x | |
| 1 | IR_2 | SLOW AHEAD | Upstream of the incident | To provide advanced notice that drivers will have to slow down. | | | | x | |
| 1 | IR_2 | Flashing arrow to the right | Upstream of the incident | Drive on the shoulder | | | | x | |
| 1 | IR_2 | COLLISION ON EXIT 135 USE CAUTION ON SHOULDER | 2nd closest VMS | Allows the driver decide if they are going to take the exit or continue on their way. Not stating the exit is closed "Common Sense Approach" | x | | | x | x |
| 1 | IR_2 | COLLISION ON EXIT | Closest VMS | Indicates that the incident is on the shoulder and not ahead of all lanes | x | | | | x |
| 1 | IR_2 | COLLISION AHEAD USE CAUTION | Location not specified | General language that lets drivers figure out what to do on their own. | x | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 1 | IR_2 | CRASH AHEAD<br>AT LIGHT (Location)<br>USE ALT. ROUTE | A6 | Tell drivers to reroute. | x | | | x | x |
| 2 | IR_2 | COLLISION AHEAD<br>ALL LANES BLOCKED<br>TAKE EXIT 137 | VMS at B1,2,3 | If people know there is a way out they'll take it. | x | x | | x | |
| 2 | IR_2 | ALL LANES BLOCKED<br>USE ALT. ROUTE | VMS at B1,2,3 | Needs to be simple as possible. This seems simple enough | | x | | x | |
| 3 | IR_2 | A combined left/right arrow | Between F8 and F9 just in front of the incident | To tell drivers to go around the incident. | | | | x | |
| 3 | IR_2 | COLLISION AHEAD<br>2 CENTER LANES BLOCKED<br>EXPECT DELAYS | VMS Upstream and off map | This general message indicates what happened, the lanes that are blocked and what drivers can expect | x | x | | x | |
| 3 | IR_2 | COLLISION AT [ROAD NAME]<br>4-MILE BACKUP | VMS Upstream and off map | Provides information that is likely to influence drivers to reroute; or drivers will know how long they'll be in the slow-down and can better manage their expectations. | x | x | | | x |
| 3 | IR_2 | HOV USE OK<br>Or<br>HOV OPEN FOR ALL | 3rd truck upstream from the scene; off the map. | Let's drivers know they can use the HOV to get around the incident. Sign would be used for a roadway that has an HOV lane. | | | | x | |
| 4 | IR_2 | LEFT LANE BLOCKED | Not specified | Tells drivers what side of the highway the incident is on. | | x | | | |
| 4 | IR_2 | COLLISION AHEAD<br>SLOW TRAFFIC JUST AHEAD | VMS upstream of the traffic queue | Inform drivers that they are approaching a traffic jam. This message may not be in use due to presumed liability issues. | x | x | | | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 5 | IR_2 | CRASH AHEAD<br>LEFT LANE BLOCKED | Two signs at the top of the entrance ramp | Tell drivers what's going on and use cones to push them to the shoulder. Use of the lane blocked sign is because there are no alternatives. | x | x | | | |
| 5 | IR_2 | CRASH AHEAD<br>RIGHT LANE BLOCKED | Upstream from D2 | Tell drivers what's going on and use cones to push them the other open lanes | x | x | | | |
| 6 | IR_2 | RAMP CLOSED | G4 at the exit ramp entrance | Tells drivers, "You cannot go this way." Closed is more effective than blocked. | | x | | | |
| 7 | IR_2 | COLLISION<br>RIGHT TURN ONLY | On each road | | x | | | x | |
| 7 | IR_2 | NO THROUGH TRAFFIC<br>CRASH AHEAD<br>RIGHT TURN ONLY | | | x | x | | x | |
| 7 | IR_2 | USE [ROAD NAME] | Upstream on closed roads | Provides an alternate because most drivers do not know alternate routes. This would be used after deciding to close down all but the two busiest roadways. | | | | x | |
| 7 | IR_2 | CRASH BLOCKING INTERSECTION | Upstream on all approaching roads | | x | x | | | x |
| 8 | IR_2 | ROAD WORK AHEAD<br>3 RIGHT LANES CLOSED AHEAD | H1 or farther upstream | | x | x | | | |
| 8 | IR_2 | RIGHT LANE ONLY | A1 | To get southbound traffic to merge to the right lane and be in the correct lane after crossing the intersection | | | | x | |
| 1 | GP_1 | EXIT CLOSED DUE TO ACCIDENT | VMS | For trucks to get them to exit before they get to the accident scene. | | x | | | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 1 | GP_1 | INCIDENT<br>EXIT XX<br>STAY TO RIGHT | | When they come up on the incident instead of looking and trying to figure out what to do, they just know they should go along the shoulder as if they were exiting normally. | x | | | x | x |
| 1 | GP_1 | EXIT CLOSED<br>USE NEXT EXIT | | Have people go past this so they aren't queuing up and then open the ramp again once it is cleaned up. | | x | | x | |
| 2 | GP_1 | INCIDENT AHEAD<br>RIGHT LANE CLOSED | | | x | x | | | |
| 2 | GP_1 | BE PREPARED TO STOP | | | | | | x | |
| 2 | GP_1 | ALL LANES CLOSED<br>ACCIDENT AHEAD<br>USE ALT. ROUTE | VMS | Get the message to people as far back as you can to decrease the traffic closer to the scene. | x | x | | x | |
| 2 | GP_1 | INCIDENT<br>KEEP LEFT | | To get people to use the shoulder to go around the incident | x | | | x | |
| 2 | GP_1 | INCIDENT<br>KEEP RIGHT | | Make people take the exit to get off the road. | x | | | x | |
| 2 | GP_1 | INCIDENT<br>ALL LANES CLOSED<br>USE ALT. ROUTE | | | x | x | | x | |
| 2 | GP_1 | ACCIDENT<br>ALL LANES CLOSED<br>USE EXIT | VMS | | x | x | | x | |
| 2 | GP_1 | KEEP FAR LEFT OR EXIT | | | | | | x | |
| 3 | GP_1 | ACCIDENT<br>USE LEFT LANE ONLY<br>or<br>USE RIGHT LANE ONLY | Near accident scene | Get people to go around the accident | x | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 3 | GP_1 | ACCIDENT<br>LEFT LANE<br>USE HOV LANE ONLY | G3 | | x | | | x | |
| 3 | GP_1 | CENTER LANE<br>MERGE TO HOV LANE NOW | 2 miles back | Clear incident to one side and then move the traffic around. | | | | x | |
| 3 | GP_1 | INCIDENT 2 MILES AHEAD<br>MERGE NOW | 2 miles back | To get people to go as fast as possible around the accident. | x | | | x | x |
| 3 | GP_1 | ACCIDENT AHEAD<br>USE ALT. ROUTE | | | x | | | x | |
| 4 | GP_1 | Combined left/right arrow | PCMS mounted to back of IR truck | Get people to go around on either side of accident | | | | x | |
| 4 | GP_1 | ACCIDENT AHEAD<br>USE FAR 2 RIGHT LANES | F8/G8 | Go around and what lanes to use. | x | | | x | |
| 4 | GP_1 | X | VMS | Tell people what lanes are open and what lanes are closed | | x | | x | |
| 4 | GP_1 | MERGE | F2 | | | | | x | |
| 4 | GP_1 | Cones with an arrow sign | DOT Truck near accident. | Tell people that they need to merge over to get around the accident. | | | | x | |
| 5 | GP_1 | EXIT CLOSED<br>ON RAMP CLOSED | | | | x | | | |
| 5 | GP_1 | GO LEFT/MOVE LEFT | C2/C3 | Get them to move now. Action words. | | | | x | |
| 5 | GP_1 | MERGE LEFT | C2 | | | | | x | |
| 5 | GP_1 | ON-RAMP CLOSED | On adjacent road | | | x | | | |
| 5 | GP_1 | EXIT AHEAD<br>USE FAR LEFT LANES ONLY | Past A section | | | | x | x | |
| 6 | GP_1 | EXIT CLOSED<br>MERGE LEFT | | | | x | | x | |
| 6 | GP_1 | EXIT CLOSED<br>USE NEXT EXIT | F9 | Get people off the road | | x | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 7 | GP_1 | ACCIDENT AHEAD<br>RIGHT TURN ONLY | | | x | | | x | |
| 7 | GP_1 | LANE CLOSED<br>RIGHT TURN ONLY | | | x | | | x | |
| 8 | GP_1 | ALL LANES BLOCKED | H3 | To tell drivers not to go this way, and to keep traffic from building up at the incident | | | | | |
| 1 | GP_2 | EXIT XX CLOSED<br>USE NEXT EXIT | | Will eliminate slow-downs because they will see it and go around. | | x | | x | x |
| 1 | GP_2 | EXIT XX CLOSED<br>USE EXIT XX | (Repeating) | | | x | | x | x |
| 1 | GP_2 | EXIT CLOSED<br>USE NEXT EXIT | | Don't include specific numbers so it can be generalized to other scenarios. | | x | | x | |
| 1 | GP_2 | ACCIDENT AHEAD<br>MOVE TO SHOULDER | | | x | | | x | x |
| 1 | GP_2 | INCIDENT AHEAD<br>BE PREPARED TO STOP | A1 (on VMS) | Problem Ahead | x | | | x | x |
| 1 | GP_2 | DO NOT PASS | E4 | Keeping Cars from side-by-side stacking | | | | x | |
| 1 | GP_2 | MERGE RIGHT | E6 | Generic message that signals intent telling drivers to use the right shoulder | | | | x | |
| 1 | GP_2 | USE SHOULDER | F1 | A more specific message | | | | x | |
| 1 | GP_2 | EXIT XX BLOCKED + RD #<br>USE ALT. ROUTES<br>EXPECT DELAYS? | B1-B2 | An attempt to re-route traffic to prevent backup. Only the exit number used means nothing, so include the road name as well. | | x | | x | x |
| 1 | GP_2 | LANE CLOSED<br>SLOW<br>MERGE RIGHT | D1 | More information than previous signs. | | x | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 1 | GP_2 | DO NOT EXIT | West of A1 | Stay off the exit until issue is cleared | | | | x | |
| 1 | GP_2 | EXIT CLOSED | | | | x | | | |
| 1 | GP_2 | USE NEXT EXIT | | Regarding VMS:<br>Exit 63 Closed<br>Use Exit 64<br>(Accident) | | | | x | |
| 1 | GP_2 | RAMP CLOSED | A1 | | | x | | | |
| 1 | GP_2 | OVERTURNED VEHICLE<br>TAKE NEXT EXIT | E6 | | x | | | x | |
| 1 | GP_2 | ACCIDENT AHEAD<br>MOVE TO SHOULDER | | | x | | | x | |
| 2 | GP_2 | ACCIDENT AT [ROAD NAME]<br>EXIT NOW | | | x | | | x | x |
| 2 | GP_2 | I-5 AT [ROAD NAME]<br>3 LANES BLOCKED<br>USE ALT. ROUTES | As far back as possible | The desire to reroute traffic | | x | | x | x |
| 2 | GP_2 | DO NOT PASS | E8 | I would not want drivers passing in the left shoulder | | | | x | |
| 2 | GP_2 | DETOUR<br>EXIT NOW<br>ACCIDENT AHEAD | Earliest Possible on VMS 2-3 times | | x | x | | x | |
| 2 | GP_2 | EXIT<br>MERGE RIGHT | A1 and/or before A6 | | | | | x | |
| 2 | GP_2 | SLOW<br>EMERGENCY SCENE AHEAD<br>EXIT | A6<br><br>B6 | | x | | | x | |
| 2 | GP_2 | SAVE YOURSELF<br>EXIT NOW | As early as possible | Hopefully lanes will be blocked early enough to get cars to begin to merge right to exit. | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 2 | GP_2 | ALL LANES BLOCKED AHEAD<br>USE ALT. ROUTE | B1 | The desire to reroute traffic by having them exit. | | x | | x | |
| 2 | GP_2 | DETOUR | C6 | The desire to reroute traffic by having them exit. The focus here should probably be on moving the cars to get 1 lane clear ASAP rather than detouring traffic. | x | | | | |
| 2 | GP_2 | TRUCKS EXIT NOW | | | | | x | x | |
| 2 | GP_2 | CRASH AHEAD<br>LANES CLOSED | Incident Sign | Cycling description of information between location and type of accident | x | x | | | |
| 2 | GP_2 | MERGE LEFT | Further back than A1 | If incident is not potentially more dangerous in future | | | | x | |
| 2 | GP_2 | BE PREPARED TO STOP combined with lights on emergency vehicles | C1 & Further Back | | | | | x | |
| 2 | GP_2 | SLOW<br>EMERGENCY SCENE AHEAD | A1 | | x | | | x | |
| 2 | GP_2 | TRUCKS TAKE EXIT | | | | | x | x | |
| 2 | GP_2 | MERGE LEFT OR EXIT NOW | | | | | | x | |
| 3 | GP_2 | EXIT NOW<br>SAVE YOURSELF XX HOURS | | Have this sign in addition to a picture of the traffic density like the traffic report to show that there is a back-up.<br>Also possibly have show up on GPS.<br>Or link it to the traffic cams so people can see that it is horrible | | | | x | |
| 3 | GP_2 | CENTER LANE BLOCKED AHEAD | About 1-5 miles back | Giving advanced warning to avoid a certain lane | | x | | | |
| 3 | GP_2 | MERGE LEFT OR RIGHT | G3/G4 | Telling Drivers to continue on | | | | x | |
| 3 | GP_2 | SLOW/CAUTION | G3/G4 | | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 3 | GP_2 | Combined left/right arrow | G3/G4 | | | | | x | |
| 3 | GP_2 | TUNE TO 710 AM<br>FOR INCIDENT<br>INFORMATION | Radio | | | | | x | |
| 3 | GP_2 | ACCIDENT AHEAD<br>BE PREPARED TO STOP | Multiple locations up to 6-8 miles back | | x | | | x | |
| 3 | GP_2 | ACCIDENT AHEAD<br>EXIT NOW | As early as possible | Save yourself time | x | | | x | |
| 3 | GP_2 | Left or right pointing arrow | VMS | | | | | x | |
| 3 | GP_2 | EXIT NOW<br>Show color coded traffic levels | | | | | | x | |
| 3 | GP_2 | CENTER LANES CLOSED | | | | x | | | |
| 3 | GP_2 | Combined left/right arrow | | Keep it simple. Straight to the point. Less words the better. Keep the focus on the road. | | | | x | |
| 4 | GP_2 | EXIT NOW<br>GO RIGHT or GO LEFT GO SLOW | | | | | | x | |
| 4 | GP_2 | MERGE RIGHT | F8 | | | | | x | |
| 4 | GP_2 | LEFT LANE AND<br>SHOULDER BLOCKED<br>AHEAD | A mile back | | | x | | | |
| 4 | GP_2 | Right pointing arrow | F8 | Indicate to merge right | | | | x | |
| 4 | GP_2 | “X” | H8 | Indicate a lane is blocked | | x | | x | |
| 4 | GP_2 | INCIDENT AHEAD | VMS on left shoulder | | x | | | | |
| 4 | GP_2 | MERGE RIGHT | Signs from G3 back (both directions) | Integration of multiple pathways of information conveyance: signs, physical vehicles with lights, radio, computer/phones, webcams. | | | | x | |
| 4 | GP_2 | MERGE R | H8 | | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 4 | GP_2 | ACCIDENT AHEAD | | | x | | | | |
| 4 | GP_2 | EMERGENCY SCENE AHEAD<br>MERGE RIGHT | | | x | | | x | |
| 5 | GP_2 | RAMP CLOSED | At on-ramp entrance | | | x | | | |
| 5 | GP_2 | ACCIDENT AHEAD<br>MERGE LEFT | C2 & 4-6 miles back | | x | | | x | |
| 5 | GP_2 | RIGHT LANE BLOCKED AHEAD | 1 mile back | For drivers already on the freeway | | x | | | |
| 5 | GP_2 | ON RAMP CLOSED<br>USE DETOUR | Start of Ramp | For drivers getting on freeway- use another on ramp | x | | | x | |
| 5 | GP_2 | EMERGENCY SCENE AHEAD | D1 | | x | | | | |
| 5 | GP_2 | Right pointing arrow | | | | | | x | |
| 5 | GP_2 | CRASH | | | x | | | | |
| 5 | GP_2 | MERGE | | | | | | x | |
| 5 | GP_2 | ! | | Be careful, something's wrong. | x | | | x | |
| 5 | GP_2 | Left pointing arrow or right pointing arrow | | Go Right/Go Left around the wreck | | | | x | |
| 5 | GP_2 | EXIT NOW<br>2 HOUR DELAY AHEAD | ASAP | Get off the freeway | | x | | x | |
| 5 | GP_2 | RAMP CLOSED | ASAP | Don't make things worse | | x | | | |
| 6 | GP_2 | EXIT CLOSED | | | | x | | | |
| 6 | GP_2 | DETOUR AHEAD | | | | x | | | |
| 6 | GP_2 | EXIT [ROAD NAME] BLOCKED | 1-5 miles back | | | x | | | x |
| 6 | GP_2 | USE ALT. ROUTES | 1-5 miles back | | | | | x | |
| 6 | GP_2 | EXIT CLOSED<br>ACCIDENT | | | x | x | | | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 6 | GP_2 | CRASH<br>EXIT CLOSED | | | x | x | | | |
| 6 | GP_2 | DETOUR AHEAD | | | | x | | | |
| 6 | GP_2 | MERGE LEFT<br>Left pointing arrow<br>SLOW | | | | | | x | |
| 6 | GP_2 | DETOUR | | | | x | | | |
| 6 | GP_2 | RIGHT LANE SLOW | | Give people time to make a decision or merge back onto the freeway | | | x | x | |
| 7 | GP_2 | INCIDENT AHEAD | | | x | | | | x |
| 7 | GP_2 | MERGE RIGHT<br>NO THROUGH | | | | x | | x | |
| 7 | GP_2 | INTERSECTION BLOCKED<br>PACIFIC HIGHWAY & PORT OF TACOMA ROAD | | | | x | | | x |
| 7 | GP_2 | CENTER LANE BLOCKED | | | | x | | | |
| 7 | GP_2 | LEFT LANE BLOCKED | | | | x | | | |
| 7 | GP_2 | USE DETOUR | | | | | | x | |
| 7 | GP_2 | NO THROUGH | | | | | | x | |
| 7 | GP_2 | Right pointing arrow | Each corner | | | | | x | |
| 7 | GP_2 | INTERSECTION BLOCKED<br>PORT OF TACOMA RD AND PACIFIC HIGHWAY | VMS? | | | x | | | x |
| 7 | GP_2 | USE ALT. ROUTES | | | | | | x | |
| 7 | GP_2 | MERGE RIGHT<br>USE DETOURS | All of them | | | | | x | |
| 8 | GP_2 | LOCAL TRAFFIC ONLY | | | | | x | x | |
| 8 | GP_2 | MERGE LEFT/RIGHT with left and right pointing arrows | | | | | | x | |
| 8 | GP_2 | ROAD CLOSED | | | | x | | | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 1 | GP_3 | USE ALTERNATE ROUTE | Overhead VMS | So they could plan and avoid it somehow. | | | | x | |
| 1 | GP_3 | DRIVE ON SHOULDER | C1 | So they knew they couldn't drive on the shoulder itself. | | | | x | |
| 1 | GP_3 | SLOW OR CAUTION | C1 | Beware of traffic conditions ahead | | | | x | |
| 1 | GP_3 | USE SHOULDER<br>Right pointing arrow | D6 | Drive on shoulder to the right | | | | x | |
| 1 | GP_3 | INCIDENT AHEAD | D1 & D2 | So that drivers know that it's not just so roadwork going on or something like that so they know that there is an incident | x | | | | |
| 1 | GP_3 | INCIDENT AHEAD | B1 | That there was an incident ahead involving the tipped grain truck that has spilled its entire load of grain on the exit ramp therefore causing traffic to slow down. | x | | | | |
| 1 | GP_3 | SLOW | D6 | | | | | x | |
| 1 | GP_3 | RAMP CLOSED<br>SLOW DOWN | Off Ramp Freeway | To avoid hitting grain on exit ramp | | x | | x | |
| 1 | GP_3 | DRIVE ON INNER SHOULDER ONLY<br>PART OF EXIT LANE BLOCKED | Off Ramp Freeway | | | x | | x | |
| 1 | GP_3 | RAMP CLOSED | | | | x | | | |
| 1 | GP_3 | CRASH 3 MILES AHEAD | 3 miles ahead of incident | | x | | | | x |
| 1 | GP_3 | BE PREPARED TO STOP | B1 & B2 | To indicate a problem ahead | | | | x | |
| 1 | GP_3 | INCIDENT AHEAD | D6 & D7 | To indicate probable accident | x | | | | |
| 1 | GP_3 | RAMP CLOSED<br>MERGE LEFT | E1 & E2 | Cause Action | | x | | x | |
| 1 | GP_3 | EXIT RAMP PARTIALLY BLOCKED | E2 | | | x | | | x |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 1 | GP_3 | VEHICLE CRASH AT EXIT RAMP | C1 | | x | | | | x |
| 1 | GP_3 | SLOW TRAFFIC AHEAD | B2 | | | x | | | |
| 1 | GP_3 | SLOW<br>EMERGENCY SCENE AHEAD | A1 or A6 or earlier | To indicate an emergency, incident to slow traffic | x | | | x | |
| 1 | GP_3 | RAMP CLOSED | A1 or A6 or earlier | Ramp has grain and unpassable or only one side | | x | | | |
| 1 | GP_3 | USE ALTERNATE ROUTE | Sign on freeway highway – emergency one | So if heading toward can take another route and not get caught in it | | | | x | |
| 1 | GP_3 | Radio emergency on emergency channels | Radio | | x | | | | |
| 2 | GP_3 | MULTIPLE VEHICLE ACCIDENT AHEAD | A1 | Sets the scene that it's a big accident and that it's probably going to be really congested | x | | | | |
| 2 | GP_3 | MERGE LEFT | A1 or earlier | Indicating merge to left | | | | x | |
| 2 | GP_3 | EMERGENCY SITUATION AHEAD | A1 or earlier | Traffic incident or emergency situation | x | | | | |
| 2 | GP_3 | ALL LANES BLOCKED<br>USE LEFT SHOULDER | C1 or earlier | Know can't use lanes have to merge left to use shoulder | | x | | x | |
| 2 | GP_3 | USE ALTERNATE ROUTE | A1 or earlier | | | | | x | |
| 2 | GP_3 | BE PREPARED TO STOP | | | | | | x | |
| 2 | GP_3 | SLOW DOWN<br>ACCIDENT AHEAD<br>USE LEFT SHOULDER ONLY | | Driver carefully. Avoid hitting vehicles | x | | | x | |
| 2 | GP_3 | INCIDENT AHEAD<br>EXIT RIGHT OR MERGE LEFT | Beyond A1 on VMS | Get off at the off ramp if possible, otherwise you'll be passing on the right | x | | | x | |
| 2 | GP_3 | DETOUR | C6 | Follow these signs to bypass the accident | | x | | | |
| 2 | GP_3 | USE SHOULDER | C8 | Driver on this shoulder to bypass accident | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 2 | GP_3 | ALL LANES BLOCKED<br>EXIT RIGHT OR MERGE LEFT | B7 (VMS) | Helps people know the need to start choosing. | | x | | x | |
| 2 | GP_3 | EMERGENCY SCENE AHEAD | | | x | | | | |
| 2 | GP_3 | BE PREPARED TO STOP | C1 & C2 | | | | | x | |
| 2 | GP_3 | MERGE FAR LEFT | D1, D6 & D7 | Use the shoulder and get them over way left. | | | | x | |
| 2 | GP_3 | USE SHOULDER | C8 | | | | | x | |
| 2 | GP_3 | DETOUR | C6 | | | x | | | |
| 2 | GP_3 | ALL LANES BLOCKED<br>EXIT RIGHT<br>MERGE LEFT | | | | x | | x | |
| 2 | GP_3 | ACCIDENT AHEAD<br>MULTIPLE VEHICLES | CMS beyond A6 | | x | | | | |
| 2 | GP_3 | EMERGENCY SCENE AHEAD/ACCIDENT SCENE AHEAD<br>BE PREPARED TO STOP | Way ahead of accident 2-3 mile ahead (on VMS) | To let drivers know that there is an accident blocking all lanes. | x | | | x | |
| 2 | GP_3 | MERGE LEFT | B6/B7 (on LED readerboard sign on overpass) | Letting drivers know all lanes are blocked but left shoulder is open for traffic to pass | | | | x | |
| 2 | GP_3 | USE ALTERNATE ROUTES (DETOUR) | B6/B7 (On LED readerboard sign on overpass) | To allow drivers to prepare to take exit ramp or other alternate routes to avoid accident. | | | | x | |
| 2 | GP_3 | MULTIPLE VEHICLE ACCIDENT AHEAD | A1 | Providing needed information | x | | | | |
| 2 | GP_3 | EMERGENCY SCENE AHEAD | A1 | Providing needed information | x | | | | |
| 2 | GP_3 | BE PREPARED TO STOP | C1 & C2 | Providing needed information | | | | x | |
| 2 | GP_3 | MERGE FAR LEFT | D1 & D2 | Action to take | | | | x | |
| 2 | GP_3 | ALL LANES BLOCKED AHEAD | | Multi-car crash blocking all lanes | | x | | | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 2 | GP_3 | INCIDENT AHEAD | | | x | | | | x |
| 2 | GP_3 | EMERGENCY SCENE AHEAD | | | x | | | | |
| 2 | GP_3 | CAUTION USE DETOUR | | | | | | x | |
| 3 | GP_3 | ACCIDENT MIDDLE LANE | | | x | | | | |
| 3 | GP_3 | HOV LANE OPEN | H8 or earlier | Use lane to get around incident | | | | x | |
| 3 | GP_3 | EMERGENCY SCENE AHEAD | H8/H9 or earlier | Incident up ahead | x | | | | |
| 3 | GP_3 | CENTER LANE BLOCKED | H3/H4 | Center lane can't be used, merge left or right | | x | | | |
| 3 | GP_3 | Combined left/right arrow | F8 | | | | | x | |
| 3 | GP_3 | MIDDLE LANE CLOSED AHEAD | 1 mile ahead | | | x | | | |
| 3 | GP_3 | CRASH AHEAD | 3 miles back | | x | | | | |
| 3 | GP_3 | ACCIDENT AHEAD CENTER LANE | | Keep it simple and just spell it out. They know what it is. | x | | | | |
| 3 | GP_3 | SLOW | | That they need to slow down. | | | | x | |
| 3 | GP_3 | MERGE LEFT OR RIGHT | | Here are your options | | | | x | |
| 3 | GP_3 | HOV OPEN | | Here are your options. | | | | x | |
| 3 | GP_3 | USE ALTERNATE ROUTE | B4 | So the people who were close to the off ramp might be encouraged to get off | | | | x | |
| 3 | GP_3 | HOV LANE OPEN TO ALL DRIVERS | C8 | Use HOV Lane | | | x | x | |
| 3 | GP_3 | MIDDLE LANES CLOSED AHEAD | C8 | Accident Ahead | | x | | | |
| 3 | GP_3 | SLOW CAUTION | B8 | Slow Down | | | | x | |
| 3 | GP_3 | USE ALT. ROUTE | B4 | Get off at the off ramp | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 3 | GP_3 | ACCIDENT<br>MIDDLE LANE<br>SLOW DOWN/PREPARE TO STOP | | Get out of middle lane. Use alternate and outside lanes | x | | | x | |
| 3 | GP_3 | HOV LANE OPEN<br>SHOULDERS AND OUTSIDE LANES OPEN | | | | | | x | |
| 3 | GP_3 | EMERGENCY VEHICLES AHEAD<br>INCIDENT AHEAD<br>BE PREPARED TO STOP | 2-3 miles away from accident (LED sign 3 miles down) | | x | | | x | |
| 3 | GP_3 | MERGE TO LEFT/RIGHT<br>Combined left/right arrow<br>TWO MIDDLE LANES CLOSED | H9 (LED sign board on DOT Vehicle) | | | x | | x | |
| 3 | GP_3 | DETOUR<br>USE ALTERNATE ROUTES | H9 | | | x | | x | |
| 3 | GP_3 | ACCIDENT AHEAD<br>CENTER LANE | Main Sign (VMS) | Warning to slow and move left or right | x | | | | |
| 3 | GP_3 | SLOW | | Action | | | | x | |
| 3 | GP_3 | MERGE LEFT OR RIGHT<br>HOV OPEN | | Action | | | | x | |
| 4 | GP_3 | ACCIDENT AHEAD<br>LANE CLOSED | | | x | x | | | |
| 4 | GP_3 | MERGE RIGHT | G3 or G8 | | | | | x | |
| 4 | GP_3 | MERGE | D3 or F8 | | | | | x | |
| 4 | GP_3 | CAUTION SLOW | Get it out as far as you can going both directions. | There's a lot of traffic and you have the accident right there in the middle | | | | x | |
| 4 | GP_3 | LEFT LANES CLOSED AHEAD | I8, C2 | | | x | | | |
| 4 | GP_3 | MERGE | D2, F8 | | | | | x | |
| 4 | GP_3 | SLOW AHEAD | G3 | | | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 4 | GP_3 | INCIDENT AHEAD<br>BE PREPARED TO SLOW DOWN | 2-3 miles before actual incident scene | To allow drivers to know there is an incident ahead | x | | | x | |
| 4 | GP_3 | LEFT LANE CLOSED<br>PLEASE MERGE RIGHT | H3, A1 | | | x | | x | |
| 4 | GP_3 | ACCIDENT IN MEDIAN AHEAD<br>SLOW DOWN | | Don't hit truck or go into blocked lanes | x | | | x | |
| 4 | GP_3 | CRASH BLOCKING SHOULDER LANE | | | | x | | | |
| 4 | GP_3 | INCIDENT AHEAD | | | x | | | | |
| 4 | GP_3 | MOVE TO FAR LEFT OF MEDIAN | | | | | | x | |
| 4 | GP_3 | INCIDENT AHEAD<br>SLOW | A10, B8 & B9 | What it is | x | | | x | |
| 4 | GP_3 | SLOW<br>MERGE<br>LANES CLOSED | A10, B8 & B9 | Action | x | x | | x | |
| 4 | GP_3 | CAUTION<br>SLOW | A10, B8 & B9 | | | | | x | |
| 4 | GP_3 | ACCIDENT AHEAD<br>LEFT LANE CLOSED<br>MERGE RIGHT | C | Left lane closed | x | x | | x | |
| 4 | GP_3 | ACCIDENT AHEAD<br>LEFT LANE CLOSED<br>MERGE RIGHT | G3 or G8 | Left lane closed | x | x | | x | |
| 4 | GP_3 | JACK-KNIFED TRUCK IN MEDIAN<br>EXPECT SLOW DOWNS BOTH SIDES | A or H | | x | | x | x | |
| 5 | GP_3 | ACCIDENT AHEAD<br>GO SLOW | VMS located to the right of the A section | | x | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 5 | GP_3 | MERGE LEFT | D2 | | | | | x | |
| 5 | GP_3 | ON-RAMP CLOSED<br>USE DETOUR | On the shoulder at the beginning of the on ramp. | | | x | | x | |
| 5 | GP_3 | INCIDENT BLOCKING FAR RIGHT LANE | Further down on ramp | For the people who missed the initial sign | x | x | | | |
| 5 | GP_3 | SLOW TRAFFIC AHEAD | | | | x | | | |
| 5 | GP_3 | RIGHT LANE CLOSED AHEAD | | | | x | | | |
| 5 | GP_3 | CAUTION SLOW | | | | | | x | |
| 5 | GP_3 | MERGE LEFT | C1 | Merge Left | | | | x | |
| 5 | GP_3 | ACCIDENT AHEAD<br>SLOW | A4 | Be Alert, driver slower | x | | | x | |
| 5 | GP_3 | RAMP CLOSED<br>USE SHOULDER | B5 | Go to shoulder | | x | | x | |
| 5 | GP_3 | DETOUR<br>BEGINNING OF RAMP | Beginning of ramp | Take another route | | x | | x | |
| 5 | GP_3 | EMERGENCY VEHICLES AHEAD<br>ACCIDENT AHEAD<br>PLEASE USE CAUTION | 2 miles before actual accident scene (LED variable board) | To allow drivers to be aware of an accident ahead and to use caution | x | | | x | x |
| 5 | GP_3 | RIGHT LANE CLOSED<br>MERGE LEFT | ¼ mile before accident scene | To allow drivers to be aware of far right lane closure and to merge to miss accident. | x | | | x | x |
| 5 | GP_3 | SLOW DOWN<br>ACCIDENT ON SHOULDER AND 1ST ADJACENT LANE | | Avoid car and truck. Stay off blocked shoulder and first adjacent lane. | x | | | x | x |
| 5 | GP_3 | TAKE FAR HARD SHOULDER UNTIL ROAD IS CLEAR | | | | | | x | x |
| 5 | GP_3 | INCIDENT AHEAD<br>SLOW | Main sign (VMS) | What it is | x | | | x | x |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 5 | GP_3 | LANE CLOSED<br>MERGE RIGHT | C & F | Action | x | | | x | x |
| 5 | GP_3 | CAUTION<br>SLOW | Both ways | Slow for safety | x | | | x | |
| 5 | GP_3 | SLOW<br>ACCIDENT AHEAD<br>USE SHOULDER | Beginning on ramp | Accident ahead use shoulder to freeway | x | | | x | x |
| 5 | GP_3 | RAMP CLOSED<br>USE ALT. ROUTE | Beginning of ramp | Ramp closed | | x | | x | |
| 5 | GP_3 | MERGE LEFT | D2 | Merge | | | | x | |
| 5 | GP_3 | RIGHT LANE CLOSED AHEAD | B area | | | x | | | |
| 6 | GP_3 | EXIT RAMP CLOSED<br>EXIT XX CLOSED<br>USE DETOUR | G9 | | | x | | x | x |
| 6 | GP_3 | EXIT RAMP CLOSED | G9 | Don't go on it | | x | | | |
| 6 | GP_3 | EXIT XX CLOSED<br>USE DETOUR | Emergency LED sign on freeway earlier than exit | Use Detour Route | | x | | x | x |
| 6 | GP_3 | DETOUR (REPEATING) | To another/next exit | Leads to another exit/route | | | | x | |
| 6 | GP_3 | EMERGENCY ACCIDENT AHEAD | | | x | | | | |
| 6 | GP_3 | CAUTION SLOW | H8 | | | | | x | |
| 6 | GP_3 | EXIT XX CLOSED<br>EMERGENCY | G4 | | x | x | | | x |
| 6 | GP_3 | CAUTION<br>SLOW | H9 | | | | | x | |
| 6 | GP_3 | USE EXIT XX | D4 | | | | | x | x |
| 6 | GP_3 | EXIT RAMP CLOSED<br>USE DETOUR | | | | x | | x | |
| 6 | GP_3 | USE EXIT X | | | | | | x | x |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 6 | GP_3 | EMERGENCY VEHICLES AHEAD<br>USE CAUTION | 1-2 miles ahead of accident (LED VMS board) | To allow drivers to be aware of accident and emergency vehicles ahead | x | | | x | |
| 6 | GP_3 | EXIT/RAMP CLOSED<br>USE ALTERNATE ROUTES/DETOUR (VARIABLE SIGN/PHYSICAL SIGN) | H9 (1-2 miles before actual accident) | | | x | | x | |
| 6 | GP_3 | Detour signs setup to allow drivers to follow alternate route | Everywhere on alternate routes | Allow drivers who used alternate routes who don't necessarily know the alternate route know exactly where to go. | | | | x | |
| 6 | GP_3 | SLOW DOWN | | Avoid Crash on Exit | | | | x | |
| 6 | GP_3 | ACCIDENT ON EXIT RAMP<br>RAMP CLOSED<br>MOVE TO MAINLINE LANES<br>TAKE NEXT EXIT | | | x | x | | x | |
| 6 | GP_3 | ACCIDENT AHEAD<br>EXIT XX<br>CAUTION SLOW | Main Sign (VMS) | Where it is and be prepared | x | | | x | x |
| 6 | GP_3 | EXIT CLOSED | | | | x | | | |
| 6 | GP_3 | Right pointing arrow<br>EXIT XX | | Re-route cars | | | | x | |
| 6 | GP_3 | HEAVY TRAFFIC AHEAD | 3 miles back | | | x | | | |
| 6 | GP_3 | INCIDENT AHEAD | 1 mile back | | x | | | | |
| 6 | GP_3 | EXIT RAMP BLOCKED | H10 | | | x | | | |
| 6 | GP_3 | USE NEXT EXIT | G9 | | | | | x | |
| 7 | GP_3 | LEFT 2 LANES CLOSED | | | | x | | | |
| 7 | GP_3 | ACCIDENT AHEAD | | | x | | | | |
| 7 | GP_3 | RIGHT TURN ONLY | C7, D1, F2 | | | | | x | |
| 7 | GP_3 | NO THROUGH TRAFFIC AHEAD | | | x | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 7 | GP_3 | ACCIDENT AHEAD<br>RIGHT TURN ONLY | C10, A1, F3, D1 | Can only turn right at next intersection | x | | | x | |
| 7 | GP_3 | LEFT LANES CLOSED | C8, A1, F1, D1 | All lanes expect right are closed. | | x | | | |
| 7 | GP_3 | EMERGENCY VEHICLES AHEAD<br>ACCIDENT AHEAD<br>BE PREPARED TO STOP | One Sign on each direction of intersection | To allow drivers to be aware of accident ahead and emergency vehicles ahead | x | | | x | |
| 7 | GP_3 | MIDDLE LANE BLOCKED | D1 | | | x | | | |
| 7 | GP_3 | NO THRU TRAFFIC | C6 | | | | x | x | |
| 7 | GP_3 | RIGHT TURN ONLY | E3 | | | | | x | |
| 7 | GP_3 | USE DETOUR OR ALTERNATE ROUTES | D1, B1 | | | | | x | |
| 7 | GP_3 | ACCIDENT AHEAD AT INTERSECTION | | Don't go through intersection | x | | | | x |
| 7 | GP_3 | SLOW DOWN<br>TAKE RIGHT TURN LANES ONLY | | | | | | x | |
| 7 | GP_3 | INCIDENT AHEAD<br>USE RIGHT LANES ONLY | Main Signs (VMS) | What it is | x | | | x | |
| 7 | GP_3 | SLOW CAUTION | Flag signs in all 4 directions | Slow, careful | | | | x | |
| 7 | GP_3 | RIGHT LANES ONLY | Flag signs in all 4 directions | Option | | | | x | |
| 7 | GP_3 | LEFT TWO LANES CLOSED | C7, A1, D1, and F2 | Use only right lane | | x | | | |
| 7 | GP_3 | RIGHT TURN ONLY | C7, A1, D1, F2 | Use only right lane | | | | x | |
| 7 | GP_3 | ACCIDENT AHEAD<br>USE CAUTION | C7, A1, D1, F2 | | x | | | x | |
| 8 | GP_3 | CONSTRUCTION CREW<br>ROAD WORK AHEAD<br>USE CAUTION | | | x | | | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 8 | GP_3 | EMERGENCY SCENE AHEAD | | | x | | | | |
| 8 | GP_3 | USE SHOULDER ONLY | E3 | | | | | x | |
| 8 | GP_3 | SOUTHBOUND LANES RIGHT AND LEFT TURN LANES BLOCKED | | | | x | x | | x |
| 8 | GP_3 | SOUTHBOUND DRIVERS TAKE ALTERNATE LANE TO THE LEFT | | | | | x | x | |
| 8 | GP_3 | WESTBOUND DRIVERS MOVE TO RIGHT OF LANE AND PROCEED AHEAD | | | | | x | x | |
| 8 | GP_3 | ROAD CLOSED MERGE LEFT | C10 | | | x | | x | |
| 8 | GP_3 | RIGHT TURN CAUTION | E3 | | | | | x | |
| 8 | GP_3 | ROAD CLOSED [LEFT ONLY] [RIGHT ONLY] | D2 | Keep people away from sinkhole because having them drive that close to it might make it collapse more. | | x | | x | |
| 8 | GP_3 | NO LEFT TURN | B2 | | | | | x | |
| 8 | GP_3 | SB TAKE ALT. ROUTE LEFT | | | | | x | x | |
| 8 | GP_3 | ALL SB LANES CLOSED | C10 | | | x | x | | |
| 8 | GP_3 | ROAD WORK AHEAD USE CAUTION | C10 | | | x | | x | |
| 8 | GP_3 | NO THRU TRAFFIC OR CONES SET UP FOR TRAFFIC LANES | C5 and D5 | To allow traffic to go around the pavement collapse. | | | x | x | |
| 8 | GP_3 | INCIDENT AHEAD ALL SOUTHBOUND LANES CLOSED | Main Sign (VMS) | What it is | x | x | x | | |
| 8 | GP_3 | CAUTION SLOW | Both Ways | Careful | | | | x | |
| 8 | GP_3 | LEFT LANE MERGE RIGHT | D1 | | | | x | x | |

| Scenario | Group | Message | Location | Meaning | Message Elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | P | P | P | P |
| 8 | GP_3 | SOUTHBOUND LANES BLOCKED<br>FOLLOW DETOUR FOR 1 BLOCK | C7 | Can't go through | | x | x | x | |

# APPENDIX J: COMPREHENSION STUDY INTERNAL REVIEW BOARD NOTICE

**Battelle Corporate Operations**
**505 King Avenue**
**Columbus, Ohio 43201**
**Federalwide Assurance FWA0004696**
**Battelle IRB – BCO Line of Review No. IRB00000284**

**IRB 0513, Rev 2.0**
**Notice of Exemption from Federal Regulations for the Protection of Human Subjects Form**

**NOTE**: Exemption from federal regulations for protection of human subjects DOES NOT mean that the research study is exempt from Institutional Review Board (IRB) requirements or oversight. The IRB will identify any specific requirements and may require periodic status updates.

**Principal Investigator/ Project Manager:** **Justin S. Graving**

**Project Title:** **Warning Signs Legends for Emergency Incidents**

**Client/Funding Agency:** **Federal Highway Administration**

**IRB No:** **0513, Rev 2.0** **Date of Submission to IRB:** **July 2, 2014**

**Proposal No:** **OPP112651** **Project No:** **100036877**

**Contract to Battelle from:** **N/A**

**Subcontract from Battelle to:** **N/A**

**Level of IRB Review:** **Exemption from Regulation**

Meets criteria for classification as Human Subjects Research. Meets criteria for Exemption per 45 CFR 46.101(b)(2), *Interview or survey of adult subjects, **unless** information is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects AND disclosure of the human subjects' responses outside the research reasonably places the human subjects at risk or is otherwise damaging to the human subjects' financial standing, employability, or reputation.*

Final phase of research.

Minimal risk to adult participants who are licensed drivers and members of the general public. Prospective respondents will be recruited through Craigslist. Interaction requires participation in moderated focus groups, but all responses will be collected in a "response book". Demographic information collected to facilitate data analysis. Data confidentiality measures are adequate and all human subjects' responses will be reported in aggregate or as anonymous quotes. Participants will be compensated for their participation. Participation is entirely voluntary; there is no indication of coercion or undue influence. Documented informed consent is not required, but prospective participants will be provided a written "Study Briefing" that describes the purposes, risks and benefits of the study.

Any proposed changes to the testing plan or future phases of this research involving interaction with prospective participants must first be evaluated by the Battelle IRB.

**Changes in Protocol.** If amendments to study protocol or documents for IRB 0513, Rev 2.0 are anticipated, notify Gary Sapp, 614-424-7648, Room A-2-089, and submit the changes for review and approval before they are implemented.

| Reviewer, BCO Line of Review | Jyothi Nagaraja, MS | Jyothi Nagaraja | 7/07/2014 |
|---|---|---|---|
| Title | Name | Signature | Date |

Battelle Institutional Review Board (IRB)

# APPENDIX K: COMPREHENSION STUDY RECRUITMENT ADVERTISEMENT

**Participants Needed - Driving Safety Study Activity**

Battelle, a nonprofit research organization, is seeking participants to provide opinions and responses to traffic warning signs.

Requirements:

- Age 18 or over
- Licensed driver
- Drive at least 3 – 4 times a week
- Willing to share thoughts and opinions in a group setting

*Morning and afternoon sessions will be held in the South Lake Union area of Seattle the week of July 14 – 10 a.m. and 2 p.m.*

Parking will be validated

Compensation: $25 cash for ½ hour

If you are interested in participating, please email DrivingStudybattelle.org with the following information:

1. Name
2. Age
3. Gender
4. Telephone number
5. Preferred and Alternate date/time of session(s) that you are available

Please note that our return phone calls to you will show as "Unknown Caller" on mobile phones.

Thank you!

**Screening Questions**

How many times per week do you drive? – Need at least 3-4 times

Can you bring a current driver's license to your session?

# APPENDIX L: COMPREHENSION STUDY PARTICIPANT BRIEFING FORM

***This form describes the procedures of the research, what you will be expected to do as a participant, and other important information that you should consider before volunteering to participate in this research. Please read this form carefully and ask as many questions as you like before deciding whether you want to participate in this research study.***

## Purpose of the Research Study

You are being invited to participate in a traffic research study. The purpose of this study is to help evaluate road signs. You will be given a booklet to use to provide your responses.

## Procedures

The results of this study will be used to inform standards committees' on the public's opinion of road signs. The results of this study may be used to help improve traffic flow and save lives by reducing the number of traffic conflicts.

You will receive $25 for your participation today.

## Confidentiality

You will not be asked to provide any identifying information in addition to what we already know from our initial communications with you. The identifying information collected for recruitment purposes will be kept private and will not be linked with any information collected during this study. The results of this study may be published in a technical report or academic journal. Your name or any identifiable references to you will not be included in any published documentation. In order to further protect your confidentiality, all identifying information will be kept in locked cabinets during the research project. Only research staff from the research contractor, Battelle, will have access to information from this study. Upon completion of the study, all identifying information will be destroyed. Any records or data obtained as a result of your participation in this study may be inspected by the sponsor, by any relevant government agency, by the Battelle Institutional Review Board, or by the persons conducting this study, provided that such inspectors are legally obligated to protect any identifiable information from public disclosure, except as otherwise required by law. These records will be kept private in so far as permitted by law.

## Termination of the Research Study

You are free to choose whether or not to participate in this study. If you choose not to participate, you will not be penalized or lose any benefits to which you are otherwise entitled. You are also free to stop participating in this study at any time.

## Available Sources of Information

Mr. Justin Graving, the principal investigator, is available to answer any questions you have about this study. Mr. Graving can be reached at (206) 528-3268. Also, the administrative

manager of the Battelle Institutional Review Board will answer any questions you have about your rights as a research subject. The administrative manager can be reached by calling (614) 424-7648.

## ACKNOWLEDGEMENTS

The original maps are the copyright property of Google Maps® and others and can be accessed from http://maps.google.com. The map overlays were developed as a result of this research project. The overlays include lines, text, etc.

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