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16. Abstract

This project has taken a step toward defining how graphic and symbol displays can improve or assist communication with drivers. Through three human factors evaluations of alternative designs, researchers identified specific design elements that should or should not be used in graphic displays. Additionally, some of the key benefits identified for the use of graphic displays as compared to equivalent text messages are:

- A graphic display appears to improve the ability of drivers to identify available lanes in a problem area.
- The delivery of incident descriptor information (e.g. accidents or work zones) through the use of graphic symbols improves comprehension levels of non-native-language drivers (e.g., a driver whose primary language is Spanish).
- The viewing time required for comprehension by a non-native speaker may be shortened as a result of the use of graphics and symbols.
- The use of graphics makes it possible to effectively illustrate unusual operational scenarios, such as high-occupancy vehicle lanes or adjacent toll lanes, through graphic representation of roadway geometry, logos, shields, etc.

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USE OF GRAPHICS AND SYMBOLS ON DYNAMIC MESSAGE SIGNS: TECHNICAL REPORT

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Brooke R. Ullman, P.E. #95927.

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CHAPTER 1: INTRODUCTION

Dynamic message signs (DMSs) are one of the primary links a transportation agency has for communicating road traffic information to the motoring public. Although the use of DMS messages has improved freeway safety and operations, existing message design and display guidelines apply to three-line DMSs on which information is presented in alphanumeric format. Given the advances in sign technology that allow for the use of color and full-matrix image creation, transportation agencies need to consider the use of symbols and graphics to identify when this type of display can improve or assist in the communication of information to drivers. Locations where traffic flow patterns, guide sign reading requirements, and geometry are complex and require greater attention and vigilance on the part of drivers could be prime candidates for this type of display. The primary objectives of this project were to:

- answer questions concerning the ease with which drivers interpret graphic information,
- quantify message comprehension for unfamiliar elements that graphic displays could use, and
- evaluate information loading when symbols and graphics are used on DMSs.

BACKGROUND AND SIGNIFICANCE OF WORK

The following paragraphs briefly summarize some of the relevant issues involved in the use of DMSs.

- *Credibility must be maintained with DMSs.* DMSs can be effective tools for communicating with drivers. However, displaying messages that do not fulfill the information needs of drivers, are too long for drivers to read at prevailing highway speeds, or are too complex or inappropriately designed result in driver confusion and can adversely affect both traffic flow and the transportation agency's credibility.
- *DMS messages must be designed to fulfill the needs of drivers particularly when they encounter unexpected situations such as incidents, roadwork, special events, etc. in order for the drivers to make fully informed decisions (e.g., whether to take another route).* The message should include, at a minimum, a description of the problem, its location, and the recommended action drivers should take. However, the sum total of driver informational needs also includes the number of lanes closed, which lanes

are closed, degree of the problem, the effects on travel (e.g., delay), the audience for the recommended action, and one good reason for following the recommended action. When the freeway is closed completely, drivers need information about the closure and the location of the closure, which in some cases can be at a different location than the incident (*1, 2, 3*).

- *Only a few seconds are available to communicate a message.* At prevailing highway speeds, drivers are in the legibility range of DMS messages for about eight seconds or less. The amount of time drivers have to comprehend a message decreases even more when they are confronted with complex driving and traffic situations that require more time for them to devote to the driving task.
- *Some of the information needs of drivers must be omitted from three-line DMSs because the message is too long and exceeds the allowable amount of information that a DMS should or could display.* DMS messages must be clear and give drivers enough information to help them fully understand the situation and what to do but not give too much information that could lead to information overload. Therefore during most DMS signing situations, some of the information needs of drivers must be omitted from the message and not all information regarding a traffic situation can be displayed. Reducing the message to allowable lengths oftentimes results in less than optimal information being available to drivers.
- *The ability of drivers to spend sufficient time viewing DMSs diminishes when the situation (incident, roadwork, etc.), traffic flow patterns, guide sign reading requirements, and/or the geometry of the road are complex.* A major freeway-to-freeway interchange is an example of where traffic flow patterns, guide sign reading requirements, and geometry are complex and require greater attention and vigilance on the part of drivers, especially when lanes are closed on the freeway. The difficulty is even more complex for drivers unfamiliar with the area and/or English is not their primary language.
- *In some instances, the degree to which a sign promotes rapid comprehension is at least as vital as its legibility distance.* In some driving situations, a relevant sign may become visible only briefly before drivers must make a decision. In other situations, drivers may find it imperative to concentrate much of their attention on the task of operating the vehicle. Consequently, the time and attention available to

view and understand a traffic sign is severely limited. Under these situations, the driver may focus attention only briefly on the sign.

- *Symbols and graphics displays on DMSs offer potential advantages because drivers can read and understand good symbols and graphics quicker and farther upstream of the sign in comparison to word messages.* Therefore, it is possible that the use of symbols and graphics can offset some of the previously discussed limitations of word messages, particularly at high driver workload (in terms of attending to the driving task) and high information load locations such as major interchanges.
- *The development of full-matrix and other DMS hardware technologies has made it possible to display symbols and other graphic features to drivers.* Researchers envision that in the near future full-matrix DMSs capable of displaying messages in full color and allowing display flexibility will be installed at critical freeway sites. These types of signs take advantage of small size pixels that can show the whole spectrum of colors and have the computational capability of controlling the combination of colors and brightness.

CHAPTER 2: PREVIOUS RESEARCH

To effectively develop symbols and graphics to use on DMSs, one must first understand the work that has been done in two key areas. The first area is the fundamental principles of DMS word messages. From this area researchers can identify the type of information required by drivers and how DMSs can effectively communicate this information. The second area of interest is previous work that has been done regarding the use of graphics and symbols on signing. The following sections will highlight these two topics.

WORD MESSAGES

Extensive human factors and traffic operations research has been previously conducted to develop fundamental principles and guidelines for DMS message design (*4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31)*. Using these fundamental principles, Dudek has prepared guidelines for effective message design and display for TxDOT that were published in Report 0-4023-P3 *Dynamic Message Sign Message Design and Display Manual* (*1*). He previously prepared guidelines for the New Jersey Department of Transportation that were published in the report *Variable Message Sign Operations Manual* (*2*). The New Jersey guidelines were later updated for national application as part of a state pooled-funded study for the Federal Highway Administration and are published in *Guidelines for Changeable Message Sign Messages* (*3*). The guidelines developed apply to DMSs with three lines that display alphanumeric messages. The recommended messages are designed to enhance understanding and reading times with the following principles in mind:

- simplicity of words,
- brevity,
- standardized order of words,
- standardized order of message lines, and
- using understood abbreviations when abbreviations are needed.

Effective message design includes an understanding of the reading and information processing limitations of drivers. The amount of information in a DMS message is defined in terms of units of information. Dudek and Huchingson defined a unit of information as a simple answer to a question a driver might ask (*16*). Stated another way, a unit of information is each

data item in a message that a driver could use to make a decision. Each answer is one unit of information. A unit of information typically is one to three words but at times can be up to four words. The message in Figure 1 has three units of information and serves to illustrate the concept of units of information.

UNITS OF INFORMATION

Question	Answer	Info Unit
1. What happened?	MAJOR ACCIDENT	1 unit
2. Where?	PAST I-610	1 unit
3. What is advised?	USE OTHER ROUTES	1 unit

Figure 1. Units of Information Example.

Guidelines in the aforementioned DMS message design manuals state that no more than four units of information should be displayed when the freeway operating speeds are 35 miles per hour (mph) or higher. In addition, messages should be displayed at a rate of at least two seconds per unit of information. No more than eight words should be displayed in a DMS message when drivers are traveling at 55 mph, and no more than seven words should be displayed when drivers are traveling at 65 mph *(1-3)*.

While the explanation of units of information is fairly easy to understand, it is less so when using symbols and graphics to convey information. Little is known as to the informational loading characteristics of these types of displays.

Legibility of DMSs

Ullman and Dudek *(30)* recommended DMS legibility distances for message design purposes based on results of research by Stockton and Dudek (31), Dudek et al. *(19)*, Upchurch et al. *(32)*, and Ullman and Dudek *(33)*. These distances, shown in Table 1, represent standard font (all uppercase), 18-inch character heights, approximately 13-inch character widths, and about 2.5 inch stroke (pixel) widths.

Table 1. Suggested CMS Legibility Distances for Use in Message Design (ft) (*30*).

Condition	Light-Emitting Diode[A]	Fiberoptic	Incandescent Bulb	Reflective Disk
Mid-Day	800	800	700	600
Washout	800	800	700	400
Backlight	600	500	400	250
Nighttime	600	600	600	250

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs

The legibility distance affects the maximum number of units of information that a CMS should display that will allow drivers to read and comprehend the message at prevailing operating speeds. Ullman and Dudek (*30*), using the legibility distances from Table 1 and knowledge about the recommended rate of message exposure (i.e., two seconds per unit of information), calculated the maximum number of units of information that drivers can actually read and comprehend. These numbers, shown in Table 2, establish the Base Maximum Message Length.

Table 2. Maximum Number of Units of Information in CMS Message (Base Maximum Message Length) (*30*).

	Light-Emitting Diode [A]			Fiberoptic			Incandescent Bulb			Reflective Disk		
	0-35 mph	36-55 mph	56-70 mph	0-35 mph	36-55 mph	56-70 mph	0-35 mph	36-55 mph	56-70 mph	0-35 mph	36-55 mph	56-70 mph
Mid-Day	5 units	4 units	4 units	5 units	4 units	4 units	5 units	4 units	3 units	5 units	4 units	3 units
Washout	5 units	4 units	4 units	5 units	4 units	4 units	5 units	4 units	3 units	4 units	3 units	2 units
Backlight	4 units	4 units	3 units	4 units	3 units	2 units	4 units	3 units	2 units	2 units	1 unit	1 unit
Nighttime	4 units	4 units	3 units	4 units	4 units	3 units	4 units	3 units	3 units	3 units	2 units	1 unit

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs

Sign legibility distance and speed of comprehension depend to some extent on different aspects of the information displayed. It is possible that signs that are legible from great distances may not necessarily be the most readily comprehensible signs. Therefore, in addition to legibility distance, an index of the time required to extract meaning from signs is useful for evaluating sign adequacy. Information in the literature suggests that properly designed symbols and graphics have the advantage of reducing the time that drivers need to extract the meaning from signs.

SYMBOLS ON STATIC SIGNS

The use of symbols on static signs to convey information has become prevalent in the past two decades. This tendency is evident in the United States where symbolic static traffic signs are used to convey dozens of different messages. In Europe symbols are used widely on static signs in lieu of word messages for a variety of regulatory, warning, and guidance applications because of the language differences among the countries.

The results of field and laboratory experiments by a number of researchers including Dewar and Ells (*34*); Jacobs, et al. (*35*); Dewar and Swanson (*36*); and Ells and Dewar (*37*) indicate that good symbolic messages have a number of advantages over word messages.

- The signs are more legible for a given size and at shorter exposure durations.
- The signs are more easily recognizable when the information is degraded due to poor environmental legibility.
- Drivers can extract information more quickly from symbols and pictographs than word messages.
- Drivers who have difficulty understanding text messages are able to comprehend pictographs.

Research has also been conducted to evaluate driver understanding of symbols used on static regulatory and warning signs, including studies by Texas Transportation Institute (TTI) researchers Hawkins et al. (*38*), Koppa and Guseman (*39*), and Womack et al. (*40*). In the most recent study by Hawkins et al., TTI researchers evaluated many symbol signs contained in the *Texas Manual on Uniform Traffic Control Devices* (TMUTCD) (*41*). A total of 2414 drivers participated in human factors studies that included focus group studies and surveys conducted in both the English and Spanish languages. The results indicated that most drivers understood the majority of the regulatory and warning symbol signs. However drivers do not wholly understand some symbol signs. The significance of the findings in the literature relative to the current project is that transportation professionals must give careful consideration to the design of symbols and graphics intended for display on DMSs to ensure that drivers understand the meaning of the symbol or graphic.

PICTOGRAMS ON DYNAMIC MESSAGE SIGNS

In Europe, symbols are referred to as *pictograms* when they are displayed on DMSs. DMSs in Europe display many pictograms, including a number of regulatory and warning messages. In addition, pictograms are used (by international agreement) to inform drivers of situations that adversely affect their travel (e.g., crash, congestion or queue, fog, slippery road, oncoming vehicle, etc.).

Pictograms are reported to have the same advantages as those described for symbols on static signs. However, research indicates that some pictograms can cause comprehension problems for drivers who are not familiar with the design.

One of the first studies on pictograms was conducted in the Netherlands and was reported by Riemersma et al. (*42*). Researchers evaluated pictograms adapted from existing European static sign symbols as well as newly designed pictograms with regard to comprehension. Alternative pictograms for the following types of messages were studied:

- crash,
- roadwork,
- congestion or queue,
- fog,
- slippery road,
- two-way traffic,
- crosswinds,
- drawbridge,
- hydroplaning,
- skidding danger due to ice or snow, and
- reduced visibility due to rain or snow.

The results indicated that the pictograms for roadwork, congestion or queue, slippery road, two-way traffic, and drawbridge were adequate for use. The pictograms tested for crash, skidding danger due to ice or snow, and reduced visibility due to rain or snow were less acceptable. The pictograms for fog and hydroplaning were highly inadequate.

Luoma and Rama (*43*) evaluated pictograms via interviews of 795 drivers in the countries of England, Finland, France, Germany, Greece, and the Netherlands. The researchers evaluated alternative pictograms for eight different signing objectives:

- crash,
- congestion or queue,
- fog,
- slippery road,
- oncoming vehicle,
- restricted lane for buses,
- restricted lane for high-occupancy vehicles (HOVs), and
- diversion.

The researchers found that more than 86 percent of drivers understood two of the pictograms for congestion or queue. Ninety-one percent of the drivers understood one of the pictograms for slippery road conditions.

Comprehension of the other pictograms was less than satisfactory. The percent of drivers who understood the crash pictograms ranged between 66 and 72 percent. The most understood pictogram in each of the other categories had the following comprehension values: fog (17 percent), oncoming vehicle (25 percent), restricted lane for buses (51 percent), restricted lane for HOV (1 percent), and diversion (23 percent).

As part of a research project to study warning messages for use on portable DMSs in the United States, Knoblauch et al. (*44*) evaluated five pictogram messages namely congestion or queue (European), crash (European), advance flagger, lane reduction transition, and two-way traffic arrows. The pictograms were displayed on a 40- by 96-pixel portable DMS. A total of 73 participants viewed the pictograms from the following distances: 910 ft, 740 ft, 570 ft, and 400 ft. Studies were conducted during the day and night.

Knoblauch et al. found that 92 percent of drivers correctly interpreted the European pictogram for congestion or queue during daylight conditions when they viewed the sign at the shortest distance (400 ft). However, less than 50 percent correctly interpreted the message at the other distances. Also, the researchers stated that potentially dangerous meanings were frequently associated with the message. The most common potentially dangerous meaning involved the

participants believing the pictogram indicated three lanes ahead. Comprehension levels at night were even lower than in daytime conditions.

The European symbol for a crash (ACCIDENT AHEAD) was correctly seen at the two closest distances both day and night but not at the farthest distances. Knoblauch et al. suggested that some graphical redesign is in order.

The advance flagger pictogram performed reasonably well at the closest distance. However, there were potentially dangerous meanings associated with the message at the other distances. Similar results were reported for the lane reduction transition pictogram. The two-way traffic pictogram was both very visible and had high comprehension. The frequency of potentially dangerous meanings was not as high as it was for the other pictograms evaluated.

GRAPHICAL ROUTE INFORMATION PANEL

A graphical route information panel (GRIP) is a sign that graphically displays parts of a road network and in color-coded form can display relevant information such as the location and degree of congestion on segments of the road network. The use of color to display real-time information to drivers in a GRIP format was a concept that Dudek and Jones (*29*) investigated for TxDOT in the early 1970s. The results of human factors studies conducted by the two researchers in Houston and Dallas indicated that drivers preferred unique design features such as color to distinguish between normal and abnormal conditions.

GRIPs are intended to be placed at strategic locations in advance of major driver decision points and alternative routes where the network itself and/or the traffic situation are very complex. Japan has used such signs since 1980; Australia has signs displaying travel time and traffic level; and experimentation is beginning to increase in the Netherlands.

In addition to the advantages cited earlier for symbols and pictograms, researchers have reported that GRIPS have the following advantages over word messages (*45*, *46*, *47*, *48*).

- More information can be given.
- Complex information becomes easier to understand. This can be important when congestion occurs on several locations in a network or when the network is complex.
- Drivers are able to figure out where on the network a crash has occurred.

Information relative to drivers with different destinations can be presented simultaneously.

- It accommodates foreign travelers.

Along with the advantages of GRIPs, there are some disadvantages. Research shows that drivers who are not comfortable with reading maps do not make as good a use of GRIPs as their more map proficient counterparts.

ANIMATION AND COLOR

In a study reported by Lerner, et al. (*49*) the researchers investigated the current state of application and guidance for the use of animation and color on dynamic displays. The researchers made the following observations:

- Neither animation nor color has yet found widespread use in the United States. While a variety of examples were found, these were generally demonstration projects or one-of-a-kind applications on arterial streets.
- The United States appears to be behind various other countries in experimenting with or implementing color-coded freeway displays. While the authors did not find widespread use of animation anywhere, Japan and Australia use color and it is the subject of demonstration projects in Europe.
- DMS displays in the United States are predominantly alphanumeric text rather than diagrammatic or symbolic/pictorial. Animation and color could be used with text messages but may be more compatible with diagrammatic or pictorial displays. The capabilities offered by full-matrix DMSs for using images, animation, and color do not appear to have been well-considered or well-exploited.

CHAPTER 3: FOCUS GROUPS

The initial phase of this project was to identify features and applications of graphics on DMS that would be understood by and of benefit to the motoring public. Focus group studies were conducted as a means to identify critical signing needs for a variety of applications in which symbols and/or graphics on a DMS might be used. The Project Monitoring Committee (PMC) provided the TTI research team with input from the perspective of their districts regarding the types of operational situations and sites in the districts where the use of symbols and graphics on a DMS might be beneficial in improving safety and/or operations. The key situations identified during this effort were to provide incident or roadwork information:

- near a major interchange,
- prior to an interchange when an incident is on the cross highway,
- near interchanges between tolled and non-toll facilities, and
- when there are adjacent toll lanes available.

Additionally, the PMC identified the need to provide information to drivers in two situations that were not incident related. The first situation was providing routing information to assist drivers of large trucks in making driving decisions to avoid a major metropolitan area, and the second looked at the use of HOV lanes under non-typical operating scenarios (e.g., for evacuation).

Based on this input, a design team consisting of individuals within TTI with expertise in human factors, traffic operations and management, real-time information systems, and symbols and graphics met on several occasions to develop a set of initial symbol and graphic messages for focus groups to assess.

STUDY DESIGN

TTI researchers conducted a series of focus group studies in five Texas cities to determine drivers' comprehension and informational demands of potential DMS symbols and graphics. The primary objectives of the focus group studies were to:

- identify additional situations for the use of DMSs with symbols and graphics,
- identify critical signing and information needs from the perspective of road users for a variety of situations, and
- provide TTI researchers with an appraisal of the initial symbol/graphic sign designs.

Each focus group was divided into five sections based on the operational situations identified by the PMC. These sections were as follows:

1. Incidents/roadwork downstream of freeway-to-freeway interchanges
2. Incidents/roadwork downstream of freeway-to-tollway interchanges
    - Normal operating conditions
    - Suspended toll conditions
3. Incident/roadwork with adjacent toll and free lanes
    - Normal operating conditions
    - Suspended toll conditions
4. Use of HOV lane during evacuation
5. Routing large vehicles around central business districts (CBDs)

Focus Group Protocol

The purpose of the focus group discussion for this project was to obtain opinions, perceptions, and input regarding the symbol and graphic message designs. Researchers used the focus group method to trigger a chain of responses by individual participants that would encourage other individuals to want to express their ideas and expose their feelings as the level of excitement over the topic increased in the group. Researchers wanted to gather suggestions and recommendations that could be used in Human Factors Laboratory Studies to be conducted later in this project as a means of assessing driver understanding.

Two TTI research project team members participated in each focus group session. One served as the facilitator (moderator) while the other took notes and interjected questions when appropriate. The researchers emphasized that the topics did not necessarily have any right or wrong answers and that the suggestions or recommendations made by the participants would be useful in guiding future research activities.

Upon arrival, participants were given a verbal explanation of the study and a participant information form to complete. At this point self-introductions were made to familiarize the participants with one another. During the introductions, the participants were also asked to share their experience with using the information that they had seen displayed on dynamic message signs as a commuter. This question was used to help motivate the participants to think of past trips when they had seen and/or used this type of information when it was displayed on DMSs.

Following this introduction, researchers displayed candidate graphics on a screen for the group to view. The signs were displayed throughout the discussion (i.e., no viewing time limit was used), and participants were asked questions to investigate their interpretation of the graphics as well as to obtain information on how they believed the graphics could be improved.

During each focus group session, the researchers (facilitators) followed a detailed discussion guide prepared for the project. The focus group guide was tailored to the local area of the particular city in which the group discussion was held. In other words, street names and scenarios used within the group discussions were changed as appropriate for the area. One exception to this was the focus group that was held for drivers of large trucks, where researchers used the San Antonio guide as this group was targeting truck drivers from south Texas who would drive through major urban areas in Texas as part of their long haul routes. Appendix A includes an example of the guide. Each session was kept to approximately two hours to minimize participant fatigue.

Locations

The focus group discussions were held in the following five Texas cities selected by the PMC: Brownsville, Dallas, El Paso, Houston, and San Antonio. The focus group discussions were held at the TTI facilities in Dallas, Houston, and San Antonio. The El Paso group discussion was held in a hotel meeting room, and the Brownsville group discussion was conducted in a classroom facility at a trucking company.

Participants

For four of the study locations, TTI researchers recruited 7 to 10 drivers who were local commuters, traveled at least 8000 miles per year, and traveled at least 8 to 10 times a year on freeways. These criteria were used to ensure that the participants were frequent drivers that were familiar with their roadway system and the usage of DMS messages. For the four focus groups, excluding the truck drivers focus group, there were 38 participants. The goal was to select a sample of drivers based on the demographics of the driving population of Texas with regard to gender, age, and education level. Statistics regarding age and gender were obtained from the Texas Department of Public Safety. Researchers obtained education level information on the Texas driving population from the United States Census. Table 3 shows the demographic sample needed based on cross-referencing the gender, age, and education level of the Texas

population. The numbers in italics represent the sample population obtained. With the demographic requirements along with recruiting and scheduling difficulties at some of the study locations, researchers did not quite reach their goal as outlined for the sample population. As shown in Table 3 the actual sample had a slightly higher number of female drivers (22 compared to 19). The sample was also a little lower in the age category of 18 and 39, and slightly larger in the 55+ category than the Texas driving population.

Table 3. Demographic Sample.

Age	High School Diploma or Less (50%) 18.5 Needed		Some College+ (50%) 18.5 Needed		Total	
	Male	Female	Male	Female	Numbers	Percentages
18-39	(4.5) *4*	(4.5) *2*	(4.5) *4*	(4.5) *7*	(18) *17*	(47) *45*
40-54	(2.75) *2*	(2.75) *5*	(2.75) *2*	(2.75) *2*	(11) *11*	(29) *29*
55+	(2.25) *1*	(2.25) *3*	(2.25) *3*	(2.25) *3*	(9) *10*	(24) *26*
Total	(9.5) 7	(9.5) *10*	(9.5) *9*	(9.5) *12*	38	100

NOTE: Numbers in italics represent the sample population obtained.

In the final focus group, researchers wanted to include participants who were Spanish speaking as well as drivers of large semi-trucks who are involved with long-haul operations as this is believed to be a significant portion of the drivers who travel through the major urban areas of Texas, and also a group that would greatly benefit from the use of graphics on signs. To this end, researchers recruited 11 semi-truck drivers to participate in the Brownsville focus group. Three of these participants did not speak English; however, the other bilingual members of the group interpreted the discussion and responses of these drivers for the researchers. The demographics for the truck drivers were, as expected, all male with all but one member of the group having an education level of high school diploma or less. Over half of the members were in the 40-54 age category. In all focus groups combined there were a total of 49 participants.

RESULTS

Section 1 – Incident/Roadwork Downstream of Freeway-to-Freeway Interchanges

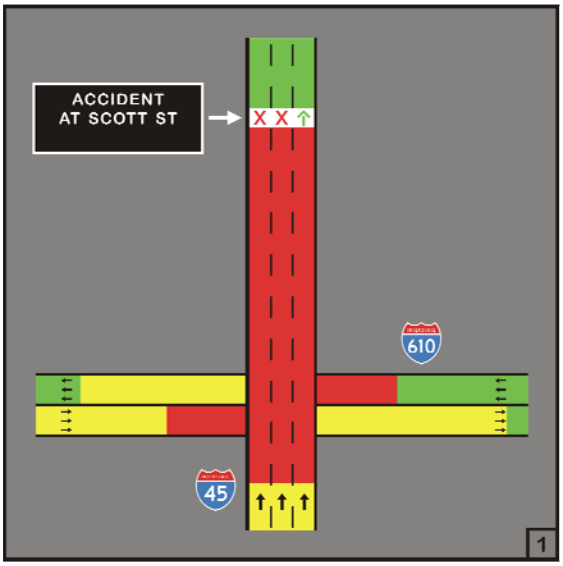
In this portion of the focus group, researchers examined two types of incident situations: unplanned incidents (accidents) and roadwork. Researchers evaluated information that would assist drivers in making good decisions about diverting and route selection including:

- incident descriptor,
- incident location,
- lanes affected,
- location of congestion, and
- degree of congestion.

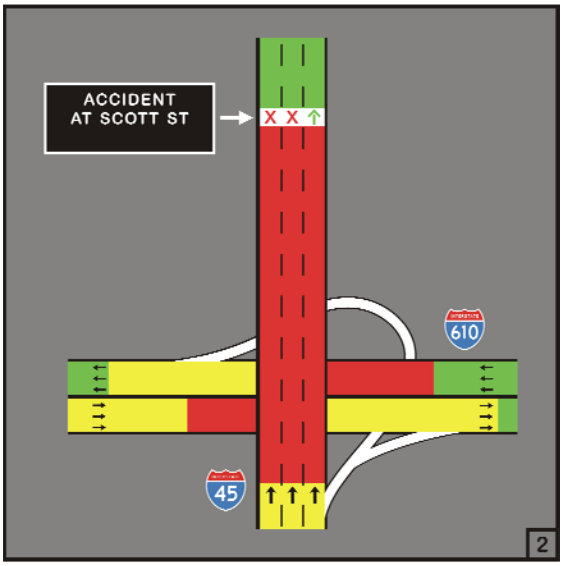
There were four graphic messages examined regarding accidents and one for roadwork. Each DMS graphic message was displayed and participants were asked what information the sign was providing to them, how well they understood the signs, and what improvements they would recommend. In addition, possible symbol designs for accidents and roadwork were examined.

Accidents

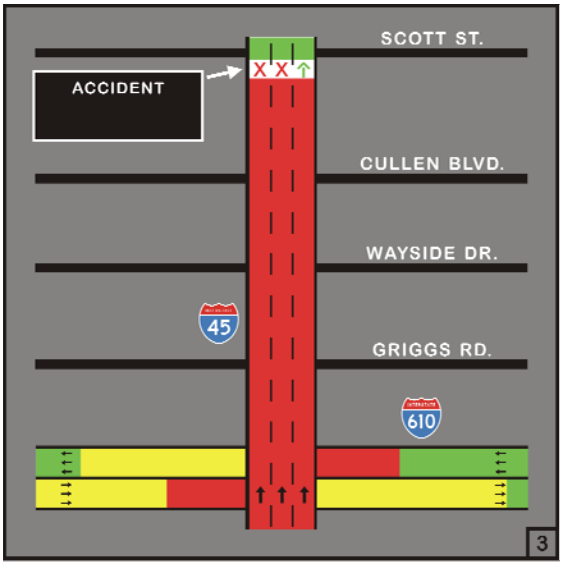
Four candidate dynamic message sign graphics shown in Figure 2 were intended to inform drivers of an accident with a two lane closure. The different graphics were categorized as the following scenarios: 1) freeway-to-freeway, 2) freeway-to-freeway with ramps, 3) freeway-to-freeway with cross streets, and 4) freeway-to-freeway in 3- Dimensional (3-D) perspective. The candidate graphics were displayed for the focus group participants one at a time to evaluate the participants understanding and opinions regarding each graphic.



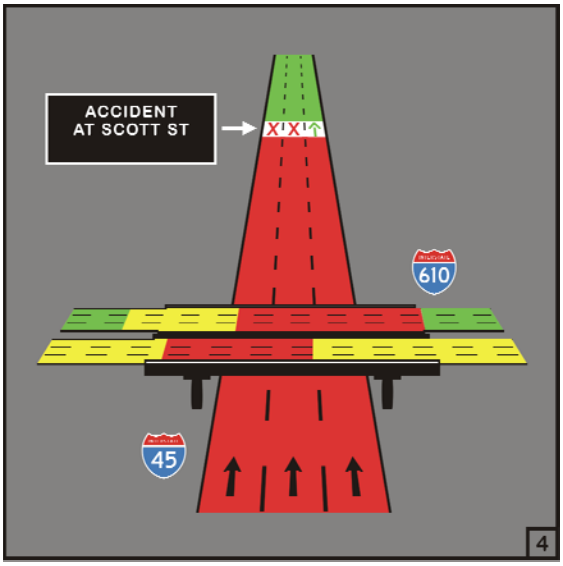
Sign 1. Freeway-to-Freeway



Sign 2. Freeway-to-Freeway with Ramps



Sign 3. Freeway-to-Freeway with Cross Streets



Sign 4. Freeway-to-Freeway in 3-Dimensional

Figure 2. Incident Freeway-to-Freeway.

Freeway-to-Freeway. All of the participants agreed that the sign was telling them that the lanes were closed and to use the right lane. Excluding Houston, the groups agreed that the graphic indicated an accident at the specific cross street shown on the DMS sign. The groups also identified the meaning of the X and arrows displayed in the lanes to mean that the two left lanes were closed and the right lane was open. In the discussion, they agreed that the dash lines

on the main freeway were necessary because it helped them to identify the number of closed or open lanes.

Generally, the participants identified the colors on the lanes as indicating congestion. However, in El Paso the participants had a slightly different interpretation of the color in the lanes and indicated that the red area meant the lanes were closed at that point and not simply slow or stopped traffic. In addition, the San Antonio group's initial reaction was that the colors provided too much information to interpret in a short time.

When asked if the sign was easy or difficult to understand, the groups in El Paso, Dallas, and Brownsville all felt that the graphic message was easy to understand; in fact, they felt the graphics were easier to understand than using word messages. In contrast, the groups in San Antonio and Houston indicated that the signs were difficult or confusing.

When researchers asked participants to identify if they would change their intended route based on the information displayed on the sign, all of the groups except the San Antonio group stated they would. There were only two individuals in the San Antonio group that stated they would change their route.

The groups had several suggestions for additional information needed if they were making the decision of whether or not to take an alternate route. These suggestions included the following:

- indicate the delay time from location of the DMS to end of red area (Dallas),
- include cross streets indicating the start and end of the congested area (Dallas),
- show alternate route (Houston and Brownsville), and
- include information on where to exit to avoid congestion (Dallas and Houston).

The final question posed to the groups dealt with suggestions of how to improve the sign displayed. There were several suggestions including the following:

- Put the highway shields on the road (Dallas).
- Include the estimated time of delay for the red area (Dallas).
- Use the circle/slash symbol (⃠) instead of an X on the closed lanes (El Paso).
- Use red color to show closed lanes but yellow in the open lane (El Paso).
- Make the open lane green (Brownsville).

Make the text box larger so it is easier to see (Brownsville).

- Add "2 lanes closed" in the text box (San Antonio and El Paso).

Freeway-to-Freeway with Ramps. The second sign discussed in this section was basically the same situation as the first, but had ramps (shown in white) connecting the main freeway and the cross freeway as shown in Figure 2 (Sign 2). The majority of the participants from all groups identified the additional white lines on the sign as either exits or alternate routes. However, several people in Dallas and Houston did not know what these lines represented. One member in the Houston group felt that showing ramps on the sign was unnecessary because most people would know where the exit ramps were located. Another member in Dallas suggested placing the freeway shield or direction of traffic on the ramps to help clarify what they were.

Overall, the majority of the participants (33 of 49) felt that the ramps made the sign more difficult to understand; in contrast, 13 participants disagreed stating the ramps made the sign easier to understand. The remaining three participants felt there was no difference between the two signs. When asked if they felt it was necessary to show the ramps on the signs, Houston, El Paso, and Dallas participants replied no, while San Antonio participants and the truck drivers in Brownsville felt it was helpful. The reasons stated for not needing the ramps were:

- they made the sign too busy,
- they were not necessary, or
- there was no real purpose for them.

Participants in favor of the ramps stated that they:

- added information to let drivers know what direction they could exit on the highways,
- helped drivers make a decision to divert by knowing the traffic conditions on the cross freeway at the point where the ramps would enter, and
- indicated to drivers that they could take the cross freeway in either direction.

Freeway-to-Freeway with Cross Streets. The next sign, Sign 3 in Figure 2, presented to the groups was again the same situation as the first but with the addition of horizontal lines representing cross streets to help drivers identify locations and possible alternate routes. All groups agreed that the lines on the signs were cross streets where they could exit from the

freeway. They all also agreed that the cross streets made the sign a lot more difficult to understand than the first sign which did not include these streets.

There were several suggestions made by the participants to improve this sign. These suggestions included:

- showing only one cross street that could be used as an exit (Houston),
- displaying the distance to the accident instead of the cross streets (Houston),
- adding the cross street name in the text box (as was done in Signs 1, 2, and 4) (Houston),
- showing only the cross street where the accident had occurred (El Paso),
- give delay time instead of the cross streets (San Antonio), and
- indicating only the streets located at the beginning and the end of the red congested area (Dallas).

When asked if the cross streets helped them to make a decision about changing their route, the responses were somewhat split. Brownsville, Dallas, and El Paso participants stated that they did help to make a decision about changing routes because it helped the drivers to know the area to avoid, and informed them where to exit the freeway. The Houston and San Antonio groups did not feel that the cross streets were helpful. They believed that it made the sign too busy and added too much information.

All of the groups agreed that it was not essential to show the cross streets on the sign. The truck driver participants indicated that it would help them to know the different exits available, but felt it would not be beneficial to other motor vehicle drivers because it would be too much information for them to take in while driving.

Three-Dimensional Perspective. As shown in Figure 2, Sign 4 had the same information as Sign 1 but was presented in a 3-dimensional perspective. All groups agreed that the sign meant the same as Sign 1, but some found this format to be unfamiliar and therefore not as easy to understand. A majority of the participants (39 of 49) felt this sign was harder to understand than the previous ones. There were eight participants that stated it was easier, while two participants felt it was the same as the other signs shown.

Accident Symbol. Four candidate accident symbols shown in Figure 3 were examined as part of the focus groups. The candidate symbols were shown as a group and researchers asked participants to identify the meaning of each symbol. The participants all agreed that Symbol A

indicated an overturned or rollover accident. For Symbol B, most of the participants from each location believed this indicated a fire. Symbol C was also interpreted as a rollover accident by the majority of the participants. All the groups identified the last symbol shown, Symbol D, as an accident (rear-end collision). Overall, all of the participants felt that the symbols all represented some type of accident. The groups all selected Symbol D as the best symbol to represent an accident. The participants felt that this symbol was the most commonly understood, and they liked that it showed more than one vehicle. In fact, when the participants were asked if they could think of a better symbol to represent an accident, the majority of the participants drew a sign similar to Symbol D.

With the exception of the Houston group, the groups felt that differentiation should be made between a major and minor accident. The suggestions made (using Symbol D) by the group to imply a major or minor accident were:

- change the color of the background (red background for major accident and yellow or green background for a minor accident), and
- use of flashing lights on edge of sign and change the flash rate (faster for more serious accident).

In addition, participants believed that there should be a separate indication used to represent hazardous material spills.

It was the consensus of the participants that Symbol D should be included in the graphic signs displayed in Figure 2. However, when asked where the symbol should be placed on the sign, the responses were quite varied. The suggested locations included:

- in the text box where the current text is located,
- on the closed lane replacing the X,
- near the road on the opposite side of where the text box is located, and
- in the gray area under the text box.

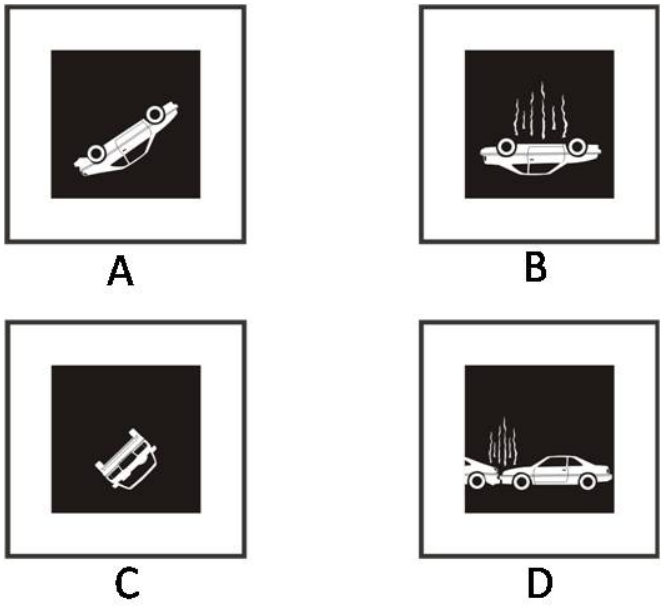


Figure 3. Accident Incident Symbols.

Roadwork

Figure 4 presents a DMS sign showing a two-lane closure and one lane open due to roadwork. Note that the sign is similar to Sign 1 in Figure 2 with the exception that the message indicates Roadwork rather than Accident, and it contains the location of the closure for each lane (shown in white). Overall, the participants understood the sign to mean roadwork and that the right lane is open and the left two lanes are closed. When asked what the white area represented, the majority of the participants indicated that it was the work area or the closed lanes. However, the participants all agreed that the white area might confuse drivers. Several group members from San Antonio recommended having the work area in red and the open lanes in green. There was a discussion in Dallas concerning the use of the color red in the work area, the participants believed this might be a better indication of the closed area; however, they concluded that this could confuse drivers as to whether the color indicated lane closure conditions or traffic speed conditions. Several individuals from Dallas suggested using orange and black diagonal stripes to indicate the work area. San Antonio participants suggested having a black and white cross-hatched area for the work area as well as placing a roadwork symbol on the road. Other suggestions included:

- adding diagonal arrows to lanes to get people to move out of the closed lanes and into the open lane,
- placing the worker symbol sign in the closed area,

- adding a man working symbol sign to the black box, or
- having orange in the work area to represent roadwork activity.

When asked if they would change their route based on the information on the sign, there was a split response in most groups. Those that said they would not change their route explained that they would simply move to the right lane. Participants made comments that the traffic does move in a construction area once you get past the merge point, and that there is less congestion with construction activity because there is less rubbernecking by passing vehicles. The group of individuals that would change their route stated that roadwork creates larger obstructions than an accident so it would be more of a problem. After discussion, the majority of the participants agreed it depended on the time of day and that if it was during the peak time period they would probably change their route.

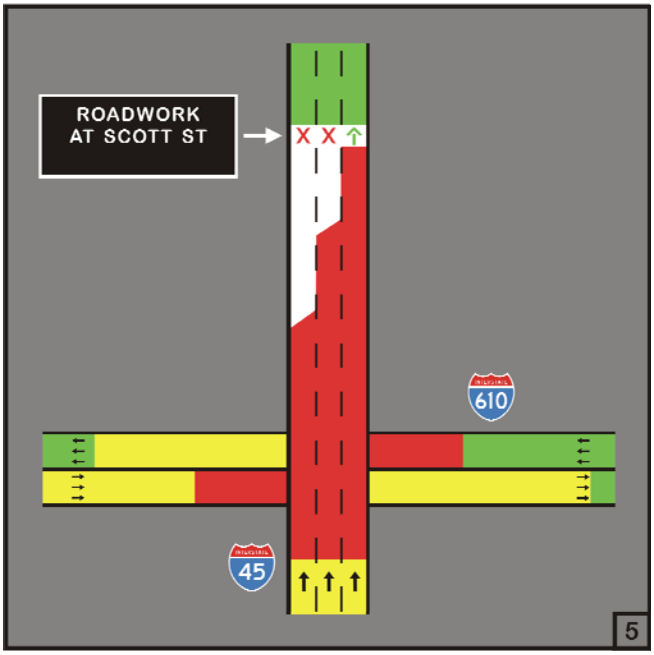


Figure 4. Roadwork – Freeway-to-Freeway.

Researchers then asked participants what other information they would need to help them make the decision whether or not to change their route. Dallas and El Paso participants suggested displaying the delay time; El Paso also recommended showing an alternate route, and/or indicating if it was major or minor roadwork. Brownsville participants felt that displaying the work hours could be beneficial.

Roadwork Symbols. Researchers next presented Figure 5 showing four different roadwork symbols and asked the participants what they thought each symbol meant. As expected, all of the participants identified Symbol A as workers or construction. The responses varied on Symbol B, with the most frequent response being a cone. Other responses included: a roller, an inactive work area, a spotlight, construction, and do not know. Symbol C was not clearly understood, with many participants stating that it meant road closed or a dead-end road. Symbol D was confusing to most of the participants who were unable to identify the symbol as anything significant. All of the focus groups agreed that the four symbols did not have the same meanings and that Symbol A was the most representative of roadwork.

The researchers then asked the groups if they could suggest a better symbol to represent roadwork. Again, the responses varied with El Paso participants suggesting adding a piece of heavy equipment placed behind the man working (Symbol A) to indicate major work. Several other participants indicated that a symbol of a hard hat could represent a work zone. However, the majority of the participants felt that Symbol A should be used because it was a standard roadwork sign and widely understood by drivers.

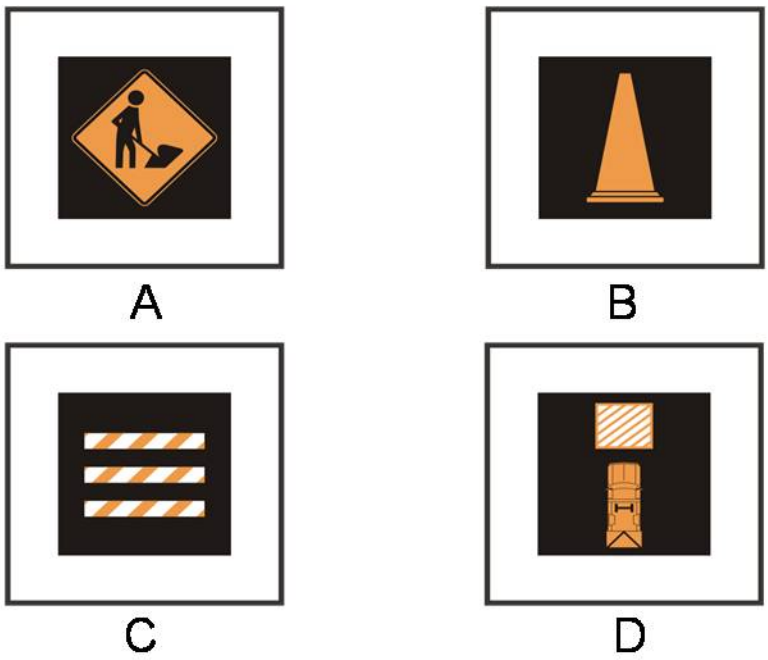


Figure 5. Roadwork Symbols.

When asked if it was important to have different symbols to indicate minor versus major delays, the truck drivers in Brownsville and the Houston participants felt it was not necessary to know the difference. They indicated that a work zone was going to slow traffic down no matter what type of work activity. San Antonio participants suggested using color to indicate severity of the roadwork; however, after some discussion the group all agreed that it was not necessary to indicate minor/major severity on the roadwork symbols. They—along with the Dallas participants—felt that drivers would like to have the delay times displayed over the severity of the roadwork. El Paso participants suggested using colors to indicate longer or shorter delay times, but, after the group engaged in a short discussion, there was the consensus that color would be too confusing.

The majority of the participants agreed that the symbol should be included in the graphic sign, as shown in Figure 4. However, the suggested placement location varied within each group. Suggestions included: in or below the text box, in the white work area, on the travel lanes, and over both lanes below the Xs. In addition, all the participants in Houston and Brownsville, and several participants from El Paso felt that the symbol needed to be included on the graphic in addition to the text but not replace it.

Section 2 – Incident/Roadwork Downstream of Freeway-to-Tollway Interchanges

In the freeway-to-tollway section researchers looked at providing the information needed by drivers to help them make an informed decision about diverting near freeway-to-tollway interchanges. The information provided in the graphic sign included:

- incident descriptor,
- incident location,
- lanes affected,
- location of congestion,
- degree of congestion, and
- tollway as the cross-highway displayed.

Two DMS graphic displays were evaluated for the freeway-to-tollway scenario. The first graphic was similar to Sign 1 in Figure 2 with the exception that the cross-highway displayed on the graphic was a tollway facility. Two different operational scenarios were discussed with relation to this graphic. The first scenario presented to the groups was when a toll payment was

required (or normal operating conditions), and the second illustrated a scenario when the toll had been suspended due to congestion caused by an incident. Participants were asked several questions regarding each situation. These questions included the following:

- What information was the sign providing?
- Would they have to pay a toll?
- What words, phrase, or symbol would indicate a toll or no toll situation on the tollway?

Additionally, researchers introduced two different toll tag symbols to determine the participants' interpretation of the symbols. The first was a toll tag symbol currently being used in Dallas and the second was the TxTag icon.

The participants were shown Figure 6, where an accident had occurred and two lanes were blocked. Researchers asked what information the DMS graphic sign provided to a driver. All of the groups identified that an accident had occurred and that two lanes were closed. Three groups (Brownsville, Dallas, and San Antonio) stated that this was the same situation as the previous graphics (as shown in Sign 1, Figure 2) only with different roads. The Brownsville, El Paso, and San Antonio groups also indicated that the cross highway was a toll road.

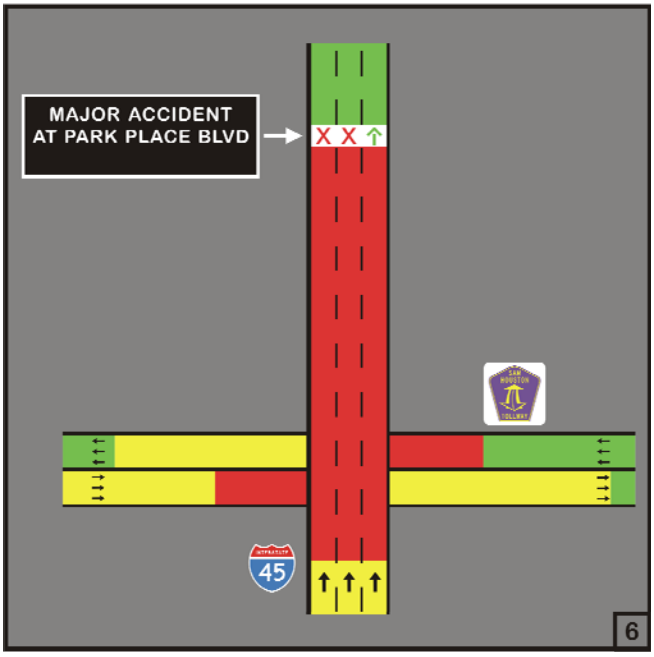


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Figure 6. Freeway-to-Tollway.

The researchers then asked the groups if the sign indicated that they would have to pay a toll when using the tollway. All participants, except three individuals from El Paso, felt that the sign implied that a toll payment would be necessary. When asked if there was any other word, phrase, or symbol that the DMS sign could include to assist drivers in knowing they would have to pay a toll, the majority of the participants felt that the toll road sign was enough information to understand the situation. However, several participants suggested placing the "$" symbol either above, near, or within the tollway sign.

It was the consensus of the groups that it was not necessary to place the lane lines on the cross street or toll road as they believed that the arrows provided enough information regarding the available lanes on the toll road.

Next, researchers introduced a scenario to the participants that a major accident had occurred on the freeway causing severe congestion and that to alleviate some of the congestion tolls had been suspended on the crossing toll road. Researchers asked the groups what word, phase, or symbol the DMS sign could include to best inform drivers that there was no charge to use the toll road. The majority of the groups agreed on the phase "No Toll." Other suggestions included:

- "Free,"
- circle/slash around the word "toll" on highway shield (⃠) or on a "$" symbol,
- "Free Toll,"
- "By-Pass," or
- "No Toll During Accident."

When asked where on the graphic sign this type of information should be placed the responses varied. Dallas participants felt it should be placed next to the tollway road sign, while Houston and Brownsville participants suggested adding it in the black text box or next to the highway sign. San Antonio participants' belief was that information regarding the tollway should not be placed in the black text box because that information was about the main highway and not the cross-highway.

Next, the focus groups were shown the tollway/toll tag symbol that is currently used in Dallas (Figure 7); however, this symbol was slightly altered to include the TxTag icon in the bottom right corner. Researchers examined this symbol to see if the participants could identify the block-T as a tollway symbol and/or if they identified the use of the TxTag symbol. Other

than the Dallas participants, who were familiar with the block-T symbol based on its local use, most participants were confused about the meaning of the block-T. The truck drivers in Brownsville stated they would guess that it meant toll road but that they were unsure. All locations, except Brownsville, agreed that the block-T was harder to understand than the tollway shield that was used in the previous graphic.

Figure 7. Tollway/Toll Tag Symbol.

The majority of the group members were able to identify the TxTag icon in this graphic as a toll tag symbol. However, even with this being true, not all of the participants knew that this symbol was being implemented statewide and that there would be one toll tag that drivers could use at toll facilities throughout Texas.

The second DMS graphic evaluated for the freeway-to-tollway scenario was a GRIP display. The GRIP DMS display presented to the participants showed the major highways within the metropolitan area and identified the location of an incident on one of the highway segments using an incident symbol (see Figure 8).

When Figure 8 was presented to the groups, most participants understood the sign, responding that the information provided on the graphic was an accident, delays, area information on traffic flow, and information for alternate route decisions. Participants suggested that the red color areas shown in the other signs where accident and delays were located would be helpful. However, their main concern was that it was too much information to understand in a short period of time. Dallas and Houston participants suggested using this type of sign on the Internet or television news but not on freeway DMSs. It should be noted that the truck drivers in Brownsville liked the GRIP format because it provided them with an overview of the traffic conditions as they approached that area which could help with route selection.

When shown the two signs, the first graphic freeway-to-tollway sign (Figure 6) and the GRIP freeway-to-tollway sign (Figure 8) side by side, the majority of the participants (35 of 49) preferred the sign in Figure 6. The reasons stated by the participants were that it showed the

specific area of concern, it was easier to read and understand, and it related to the accident better. They remarked that the GRIP sign displayed too much information, was too vague, and was difficult to understand. However, the participants who preferred the GRIP sign felt it could display a wide range of local conditions, enabled drivers to plan an alternate route better, provided more information, and let drivers know what areas to avoid.

Figure 8. Freeway-to-Tollway – Graphical Route Information Panel Sign.

When asked which of the two signs gave the most or least information to a driver, the majority of all groups felt that Figure 6 gave the least amount of information and the GRIP sign (Figure 8) gave the most. However, there were several comments stating that while the GRIP did give the most amount of information it was not giving you the information you needed, and it was hard to identify the large amount of information provided on the sign.

The researchers then asked the groups if they were traveling at a high rate of speed, which of the two signs would be easier to understand. As expected, the majority of the participants selected Figure 6, stating the GRIP sign had too much information to comprehend at that speed.

Finally, researchers gathered suggestions on how to improve the two signs. The truck drivers suggested showing them side by side so that you could get all the information, and to have the accident box flashing on the GRIP to draw drivers' attention to the fact that an accident had occurred. They also suggested including on Figure 6 the distance to the accident, and the travel time in the red zone. San Antonio and Houston participants also agreed that the delay or

travel times should be added, but they suggested placing it in the black text box of the graphics sign. Dallas participants suggested using fewer highway shields on the GRIP sign to make it look cleaner. El Paso, Dallas, and Houston participants suggested color coding the roadways to display traffic conditions as earlier signs showed.

Section 3 – Incident/Roadwork Scenario with Adjacent Toll and Free Lanes

In this section researchers examined the situation where there are adjacent toll and free lanes available for drivers to use. In this case, researchers were investigating the information needs of drivers to help make good decisions about lane and route selection. The information provided on the test graphics included:

- incident descriptor,
- incident location, and
- identification of toll lanes adjacent to main lanes.

Figure 9, showing a section of toll and free lanes running side-by-side was presented to each focus group. Similar questions as used in the previous examples were asked, such as what information the sign was providing, if it was necessary to pay to use any of the lanes, and what word, phrase, or symbol should be used to help drivers know that they would have to pay to use the toll lanes.

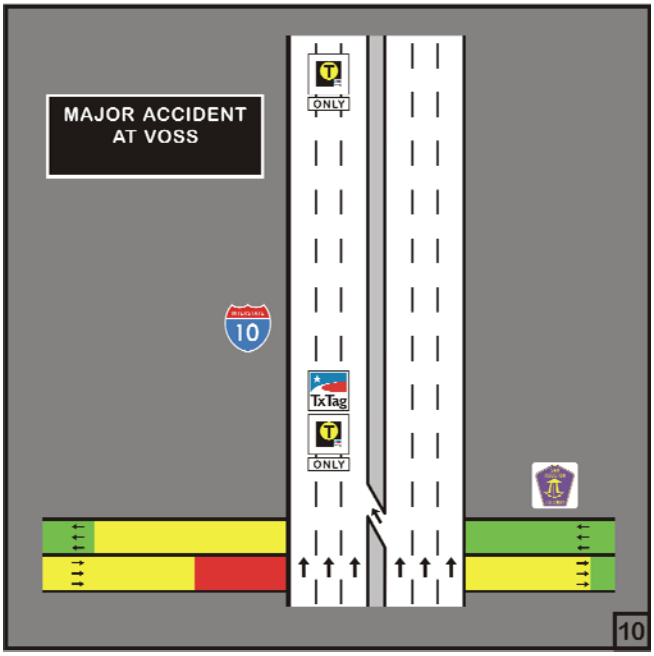


Figure 9. Freeway and Toll Lanes Side-by-Side.

When researchers asked the participants what information Figure 9 provided to drivers, there was some confusion. El Paso, San Antonio, and Brownsville participants all stated that an accident had occurred, but there was some concern as to whether the accident was on the main lanes or the toll roads since it was not specified on the sign. All of the groups except the San Antonio group felt that you could drive in the left lanes, but that you would have to pay a toll. In San Antonio half of the group agreed, but stated that they based this belief only on the previous discussion during the focus group of the symbols on the left lanes meaning tolls or toll tags. Additionally, the Brownsville, Houston and El Paso participants agreed that only toll tag holders could use the left lanes since the sign displayed "ONLY" beneath the symbol.

Most of the participants agreed that there was no need to add anything to the toll sign to help drivers know that they would have to pay a toll when using those lanes. They felt drivers should have already known they would have to pay with the information provided on the graphic. There were, however, six individuals from San Antonio that did not think the sign adequately conveyed this meaning. They suggested adding the "$" symbol beside the word "ONLY"; however, they only believed this would be appropriate if the lanes were accepting cash. Overall, there was also some confusion as to whether drivers could use cash on the toll lanes as well as paying by toll tag because the TxTag symbol did not cover all the lanes on the toll road. The participants were not sure if you could use cash in the lanes not covered by the symbol or if drivers were required to have a toll tag to use all of these lanes.

The researchers then asked the participants to assume that the major accident had caused severe congestion on the main lanes and that toll collection had been suspended for the adjacent toll lanes. Again, the groups were asked what the best word, phrase, or symbol was to include on the sign so drivers would know that there was no longer a charge to use the toll lanes. The responses were similar to the ones suggested in the previous section; these responses included:

- "Free,"
- "No Toll" on the lane,
- circle/slash over the TxTag symbol,
- remove the symbols that are on the toll lanes, or
- place "No Toll" in the text box.

When asked for suggestions to improve this sign, the majority of the participants agreed that the sign needed to state if the accident was on the main lanes or on the toll road. San

Antonio group members suggested showing the street where the accident occurred. Houston participants stated that if the accident was located on the main lanes the text box should be placed on the other side of the road (i.e., the right side of the graphic near the main lanes). Houston and San Antonio participants said they would like to know which lanes were closed by placing an "X" in those lanes as done in some of the previous signs.

Section 4 – Use of HOV Lane during Evacuation

Two DMS graphic displays were evaluated for use during evacuation situations where the HOV lane was available for all drivers to use as an additional evacuation lane. One sign had no graphic indication of exit locations and the other showed all exits existing on the HOV system. While the scenario presented in the study was evacuations during a hurricane, the use of an HOV system without restrictions could be used during any type of emergency such as an act of terrorism, plant explosions, etc. The information needs evaluated for this situation were:

- HOV lane open to all traffic, and
- distance to next exit on HOV lane.

HOV Sign without Graphic Representation of Exits

For this study the participants were told to imagine themselves in Galveston and that the city had been advised to evacuate because of a major hurricane. They were told that they were traveling from Galveston on northbound Interstate 45 when they encountered the DMS sign shown in Figure 10.

The participants all interpreted the sign to mean that drivers could use the HOV lanes regardless of the number of occupants in the vehicle, that all lanes were open during the evacuation, and that they could not exit the HOV lane for the next 17 miles. When researchers asked the participants, based on the information on the sign shown, whether they would use the HOV lanes or the main lanes, all of the participants in the San Antonio group stated they would use the HOV lanes. All of the El Paso participants and a few individuals from Dallas stated they would use the main lanes. About half of the Dallas participants and the majority of Houston participants remarked that they would use whichever lanes were moving the fastest. Incidentally, all of the truck drivers from Brownsville stated that they are not allowed to use the HOV lanes so they would travel on the main lanes.

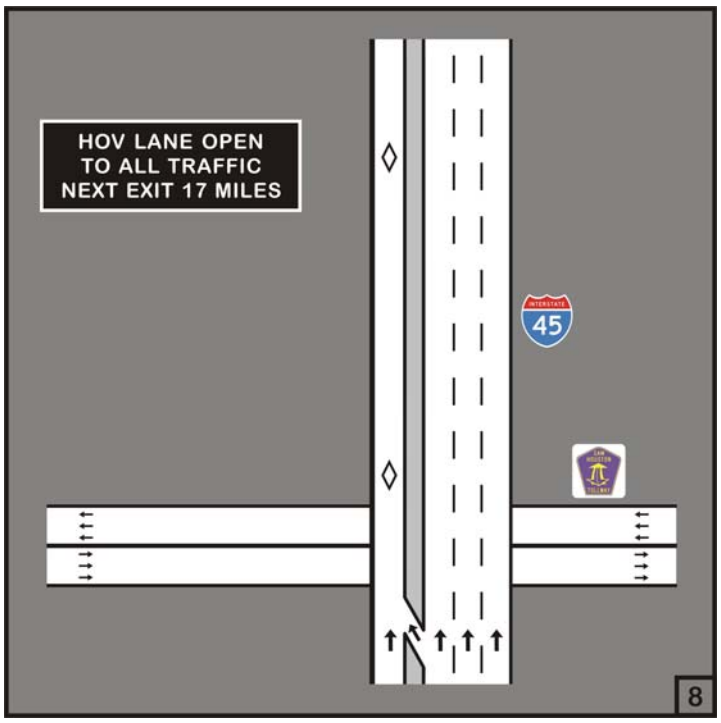


Figure 10. HOV Sign without Graphic Exit Information.

Most of the participants stated that they believed there was enough information provided on the sign to make a decision to use the HOV lanes or not; however, the Dallas participants felt there needed to be more information regarding the road conditions ahead. The other groups felt that you needed to keep the information provided simple, and that the graphic provided good information for people traveling further than 17 miles.

The focus groups provided several suggestions to help drivers determine what action they should take. These suggestions included:

- making the entrance to the HOV lane positioned higher on the sign so drivers can see conditions leading up to that point,
- using fewer words on the sign and more information provided through the graphics,
- including the names of other cross highways on the graphic,
- adding color to the open lanes (green for open and not referring to the flow of traffic),
- adding a flashing green light to emphasize that the HOV lanes are open,
- coloring all lanes as before for congestion with green arrows moving on the fast lanes and red bars on stopped lanes,

- increasing the size of the sign at the entrance of the HOV lane to focus more on the critical information, and
- showing "HOV" on the lane.

Houston participants were the only group that had suggestions on how to better inform drivers of exit information; they suggested "No Exit 17 miles on HOV," and "No Exit 17 Miles."

HOV Sign with Graphic Representation of Exits

Figure 11 illustrates an HOV lane with the addition of all exits from the HOV system shown graphically. While some of the participants suggested when the previous sign was presented that names of other cross highways should be shown, most felt Figure 11 included too much information by showing all of the exits and that the sign was confusing because it looked like two separate roads. In fact, all of the participants except one agreed that the sign with the graphical exits was more difficult to read and understand than the display in Figure 10.

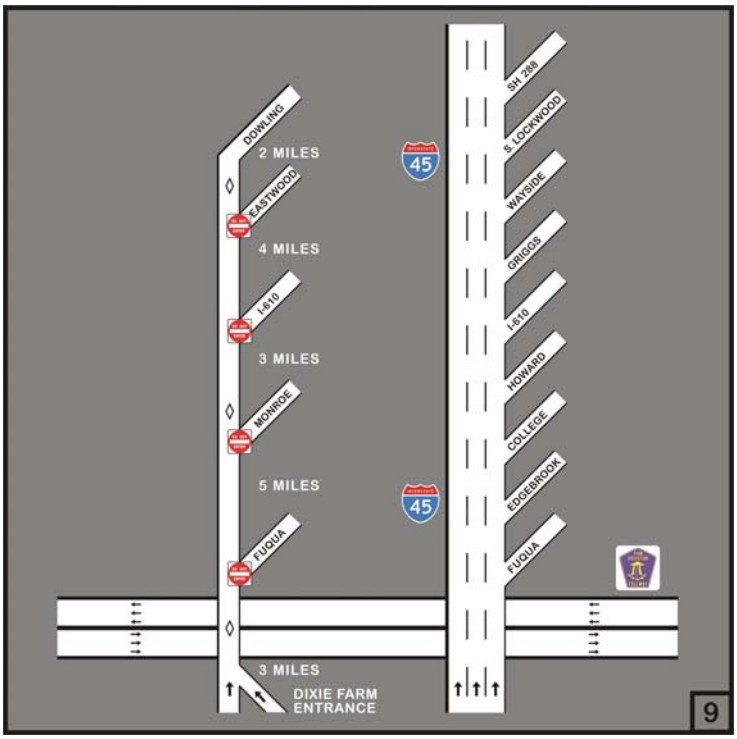


Figure 11. HOV Sign with Graphic Exit Information.

When researchers asked for changes to improve the design of Figure 11, El Paso, Houston, and Brownsville participants all agreed that the graphic shown in Figure 10 should be

used for this scenario. An additional suggestion from the Dallas group was to only include exits that they could use to leave the HOV lanes (i.e., do not show closed exits), and only major highway exits from the main lanes. San Antonio suggested removing the distance between the exits to reduce the amount of information provided in Figure 11.

Section 5 – Routing Heavy Trucks Around CBDs

While all focus groups were presented with the candidate displays for routing heavy trucks around CBDs, it was of particular interest in this study to obtain the views from the sample of truck drivers in Brownsville. The information needs examined for this sign were as follows:

- suggested truck route and
- use of toll roads by large trucks.

Each focus group was shown Figure 12 and told to assume that they were driving from the south Texas area on northbound Interstate 37 approaching San Antonio and heading to a location north of Dallas. The commuter drivers from Houston, Dallas, El Paso, and San Antonio were asked to assume that they were truck drivers when they saw this DMS sign.

Figure 12. Truck Route around CBD.

The researchers asked the groups what information they felt this sign was telling them; the commuter participants' responses varied somewhat. Some of these responses were:

- traffic clear to Dallas,
- truck route is shown,
- shows toll road that connects two major highways,
- have to go around San Antonio, and
- not sure if trucks are required to go this way.

However, all of the truck drivers indicated that the sign was clear in providing information on what route they should take: I-37 to I-10 to 130 toll road to Dallas.

Suggestions made by the general groups, as well as the truck drivers to improve the information and make it easier for truck drivers to decide which route they should take were:

- providing a truck icon on each segment of the route used,
- moving truck icons onto the road,
- placing highway shields on the road,
- coloring the road to help identify truck route, and
- using a consistent color between the truck icons near the road segments and the one in the text box.

In addition, most participants agreed that the phase "And Points North" was somewhat confusing. The truck driver participants suggested: "and Any Point North," "Points Going North," and "To Dallas and North."

SUMMARY

Overall, the basic designs presented to the focus groups for the graphics and symbols to use on DMSs were well received and understood by the participants. The following sections provide a summary of the revision suggestions made by the groups for each type of different sections of the protocol.

Section 1. Incidents/Roadwork Downstream of Freeway-to-Freeway Interchanges

With regard to the accident scenarios, the following suggestions were made.

- Move highway shields onto the road to have a cleaner look.
- Show alternate route or provide information on where to exit to avoid congestion.
- Include the estimated time of delay or travel time for the red area on the sign.
- Have a clearer indication of which lane is open.
- Place directional arrows on ramps.
- Add “2 Lanes Closed” in text box.
- Include an accident symbol within the overall graphic.
- Use color of the accident symbol to indicate major/minor accidents (red = major, yellow = minor).

With regard to the use of cross streets on these graphics, the group made the following suggestions.

- Show only the cross street where the accident occurred.
- Include cross street name of the accident location in the text box.
- Provide distance to accident instead of cross streets.
- Provide delay time instead of cross streets.
- Include name of streets at the beginning and end of the red congested area.

Finally, suggestions as related to the roadwork scenario were as follows.

- Work area should be a color other than white to indicate closed or work such as: orange, orange and black diagonal stripes, or black and white cross-hatching.
- The man working symbol should be used on the graphic.
- Delay or travel time should be provided.

Section 2. Incidents/Roadwork Downstream of Freeway-to-Tollway Interchanges

During normal operating conditions, participants made the following suggestions.

- Toll road signs are sufficient to indicate to drivers that they will have to pay a toll on a facility.
- The "$" symbol should be placed above, near, or within the tollway sign to clarify if drivers can pay the toll using cash.

For situations where toll collection has been suspended, the suggestions made were:

- Include "No Toll," "Free," "Free Toll," or circle/slash (⃠) around the word "Toll" or "$" money symbol to indicate that toll collection is suspended.
- Place the no toll information next to tollway shield or in the text box.

Suggestions related to the GRIP were:

- Too much information was provided in this format.
- Truck drivers liked the overview of the area for selecting route choices.
- Need to identify current driving location on the sign.
- Place the localized roadway graphic and the GRIP side-by-side on DMS sign to provide drivers with both the overview and the accident details.
- Include fewer highway shields on the graphic to simplify.

Section 3. Incident/Roadwork Scenarios With Adjacent Toll and Free Lanes

When under normal operating conditions, the following suggestions were made for this situation:

- Need to place toll tag symbol across all lanes to clarify that only toll tags are accepted.
- Need to indicate where accident occurred, on the non-tolled or toll lanes.
- Locate text box on the side nearest the accident location.

Participants thought one of the following indicators should be used for suspended toll conditions:

- "No Toll,"
- "Free,"
- circle/slash (⃠) over the TxTag symbol, or
- remove the symbols that are on the toll lanes and place "No Toll" in text box.

Section 4. Use of HOV Lane During Evacuation

For the HOV lane evacuation situation, participants had the following suggestions:

- Display traffic conditions through color on the lanes.
- Add an arrow pointing to the HOV lane to let drivers know it is open.
- Include HOV lane symbol (diamond) in text box or "HOV" on the lane for consistency of symbols.
- Entrance to HOV lane should be higher on the sign so drivers can see the traffic conditions leading up to that point.
- Use fewer words on the sign and provide more information through the graphic.
- Graphic should include the names of other cross highways.
- On the graphic sign increase the size of the entrance to the HOV lane to focus on the critical information upon entering the HOV lane.
- Different wording in text box for "Next Exit 17 Miles" – suggested "No Exit 17 Miles on HOV" or "No Exit 17 Miles."
- Only show exits that you can use to exit the HOV system.

Section 5. Routing Heavy Vehicles

With regard to the truck route graphic discussed, the following improvements were offered by the participants:

- Add truck icons on all segments of the intended route.
- Place truck icons on road (not beside the road).
- Place highway shields on road.
- Color road to help identify truck route.

- Consistency of color for truck graphics between the text box and the icons on the roadway.
- Change “And Points North” in text box to “And Any Points North,” “Points Going North,” or “To Dallas and North.”

CHAPTER 4: LEVEL 1 HUMAN FACTORS LABORATORY STUDY

Based on the findings of the focus groups, as discussed in the previous chapter, along with input from the PMC and the TTI expert panel, researchers developed a revised set of symbol and graphic displays that were then assessed in the Level 1 of human factors laboratory study discussed in this chapter.

STUDY DESIGN

TTI researchers conducted a laboratory study to determine driver comprehension and informational demands of candidate DMS symbols and graphics. The goal of the study was to determine and prioritize the symbols and graphics having the greatest potential for use on DMSs. The candidate graphic designs for each critical situation/site type identified by the PMC were tested to determine, at a minimum, driver understanding accuracy and comprehension times for the candidate DMS designs. The participants viewed the candidate signs displayed on a computer monitor. The capabilities of the computer allowed researchers to incorporate symbols, graphics, and color into the designs. The study was conducted by the method of self-paced viewing time. The self-paced method allowed the participants to view each message until they were confident that they understood the message. The message exposure time was recorded to ensure that the times were comparable for use in later evaluation of the different designs. The street names and locations included in the graphics were changed for each of the study locations so that the roadways would be familiar to the study participants.

Study Issues

The administration of the laboratory study was divided into five topic areas. These areas were:

1. Graphical Interchange Information,
2. GRIP Displays,
3. HOV Lane Identification,
4. Adjacent Toll Lanes, and
5. Truck Routes.

To ensure that participants were at ease with the study methodology used in each topic area, test messages were used at the beginning of areas 1, 2, and 5. Topic areas 3 and 4 did not introduce a new methodology and, therefore, researchers felt it was unnecessary to include a test message at the beginning of these areas.

Topic Area 1: Graphic Interchange Information

For this topic researchers developed six primary signs to be evaluated for driver comprehension and interpretation. Figure 13 shows the six signs; these signs were designed to specifically compare drivers' understanding and decision making based on several different graphic elements. The first element evaluated was the use of a symbol versus the text "accident." As well as evaluating driver understanding of this element, a direct preference comparison of ACCIDENT text versus an accident symbol was conducted using the signs shown in Figure 14. In addition, participants evaluated the red color symbol indicating a major accident versus the yellow color symbol (Figure 15) to indicate a minor accident.

As shown in Figure 16, four accident symbols were evaluated to determine drivers' preferences. The participants were shown all four symbols and asked what they felt each symbol meant and if they had the same meaning. Finally, the participants were asked which one of the four symbols shown best indicated an accident and why.

In the primary group of signs (Figure 13) researchers examined the need to have a green arrow placed in the right lane on the roadway to indicate an open lane and how well it would assist drivers in determining which lanes were open or closed.

In the preference portion of the study, an alternative design was evaluated that showed several sequential arrows placed in the right lane to indicate that the lane was open to drivers. This alternate sign was compared to an identical situation graphic that did not include the sequential arrows to determine which was best understood to mean the lane was open to drivers. Figure 17 shows these signs.

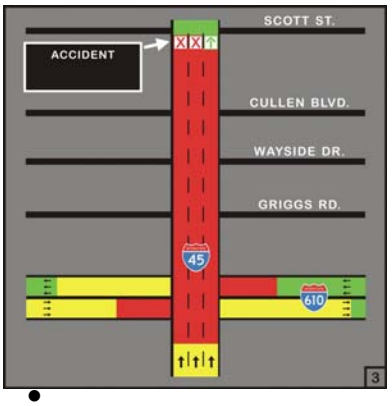
Additionally, using the signs in Figure 13 researchers assessed whether congestion information on the alternate route options would affect drivers' diversion decisions. In particular, as shown in Figure 13, Signs 1e, 3, and 4a show that there is congestion on the cross highway versus Signs 1a, 1d, and 1i where there is no congestion.

Sign 1a

Sign 1d

Sign 1e

Sign 1i



Sign 3

Sign 4a

Figure 13. Primary Signs Used in the Graphical Interchange Evaluation.

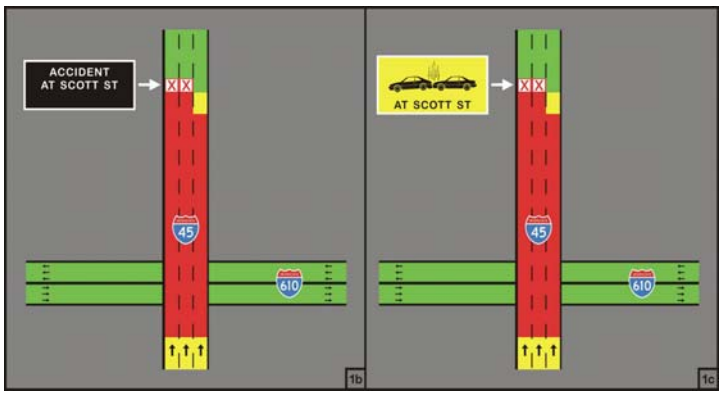


Figure 14. Signs 1b and 1c – Text versus Symbol Accident.

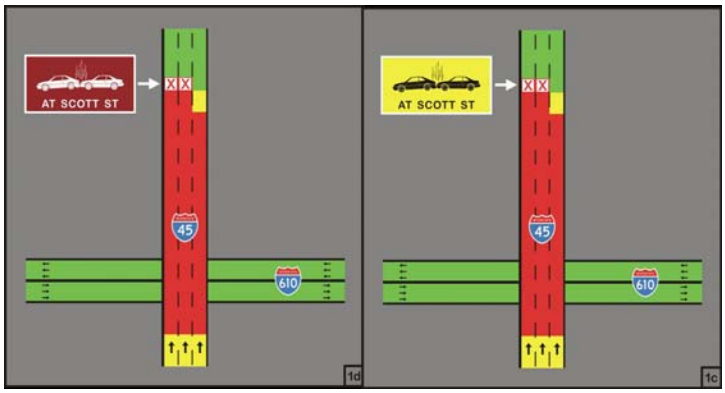


Figure 15. Signs 1d and 1c – Major versus Minor Accident by Color.

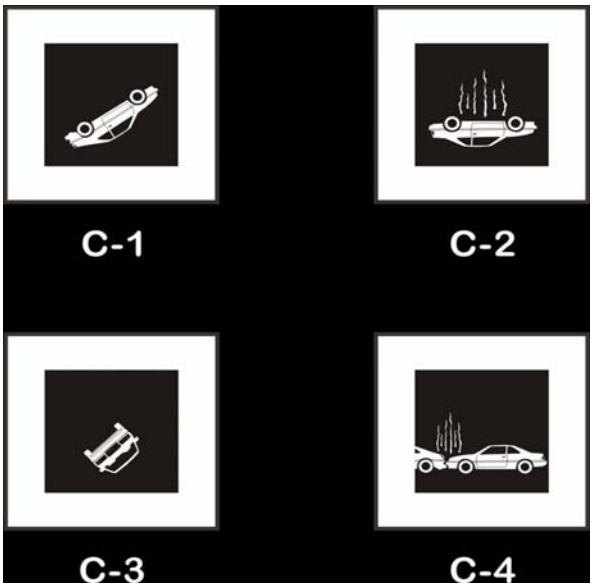


Figure 16. Accident Symbols.

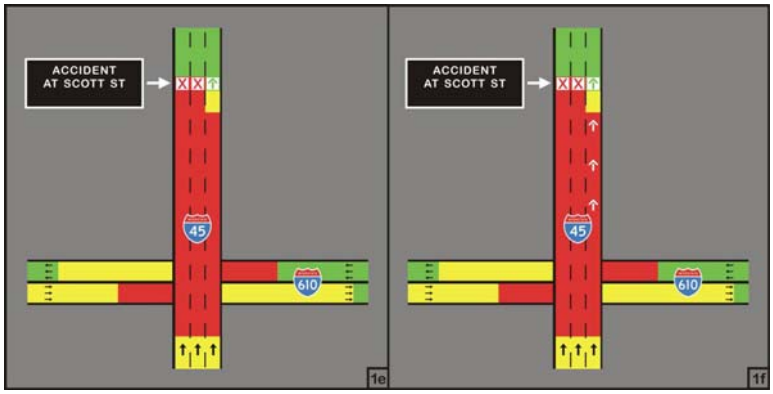


Figure 17. Signs 1e and 1f – No Sequential Arrows versus Sequential Arrows.

As an alternative to provide drivers with a more realistic perspective of the roadway, a three-dimensional graphic was developed. As shown in Figure 13, Sign 4a, this graphic gives the perception of an overpass with exit ramps. Researchers wanted to determine if this type of perspective would affect drivers' understanding of the information provided. Participant's preference was also obtained by showing Figure 18 with Signs 2 and 4a, a non-perspective view next to a perspective (3-D) view, each with ramps.

The ramps in Figure 13, Sign 4a were used to determine if drivers would interpret the ramps as a direct connection to the freeway interchange. To assess the drivers' preference of the view with ramps or without ramps, Figure 19 was shown to the participants.

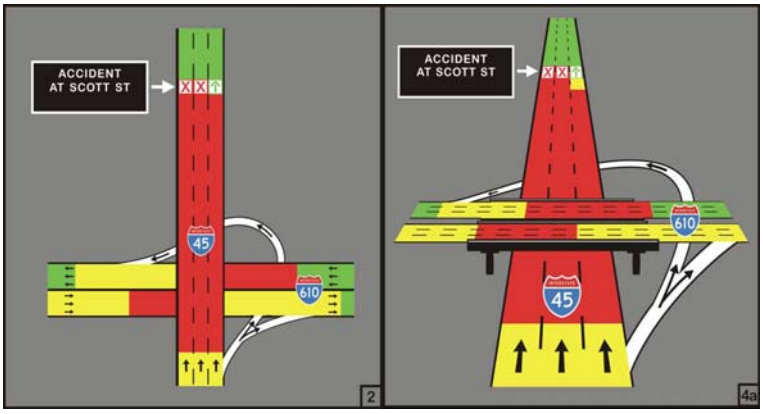


Figure 18. Signs 2 and 4a – Plan View versus Perspective View with Ramps.

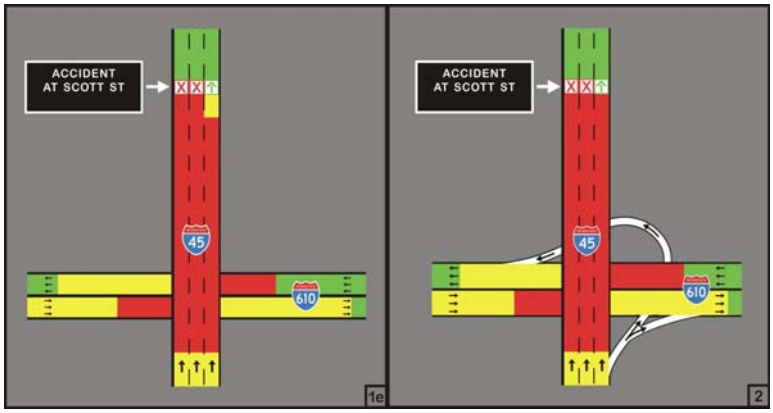


Figure 19. Signs 1e and 2 – No Ramps versus Ramps.

Researchers also evaluated drivers' preferences on the use of cross streets to identify an accident location. Two different evaluations were conducted. The first evaluation was of the use of multiple cross streets versus only one cross street, as shown in Figure 20. The second comparison, as shown in Figure 21, identified drivers' preference of a single-cross street to identify the location of an accident versus the standard text representation of location.

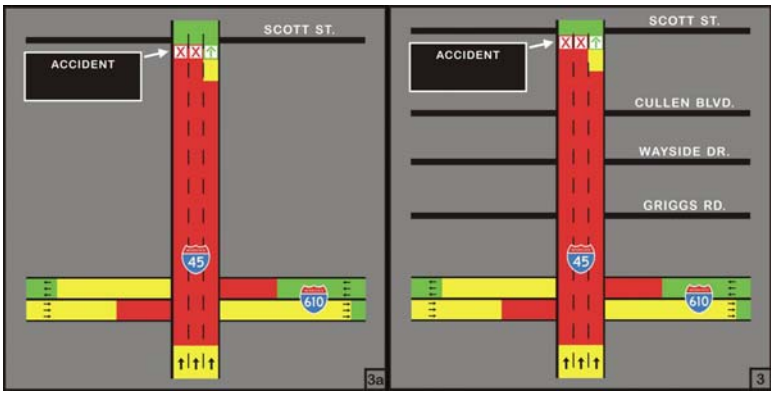


Figure 20. Signs 3a and 3 – One Cross Street versus Four Cross Streets.

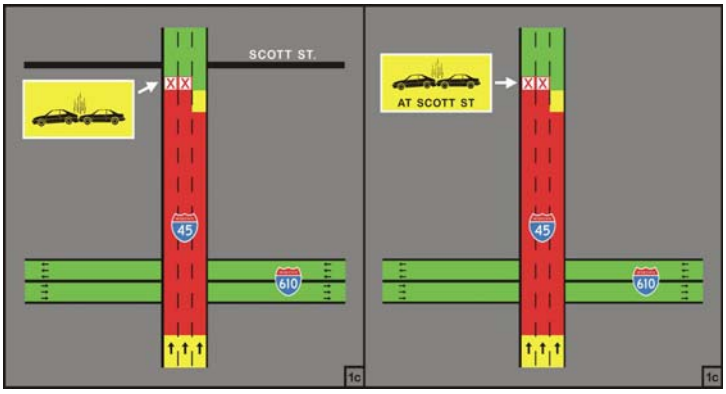


Figure 21. Single Cross Street versus Standard Text Used to Identify Accident Location.

Figure 22 shows the two signs used to evaluate drivers preference of a work zone symbol versus the text "roadwork," as well as their understanding of the graphical representation of a lane closure.

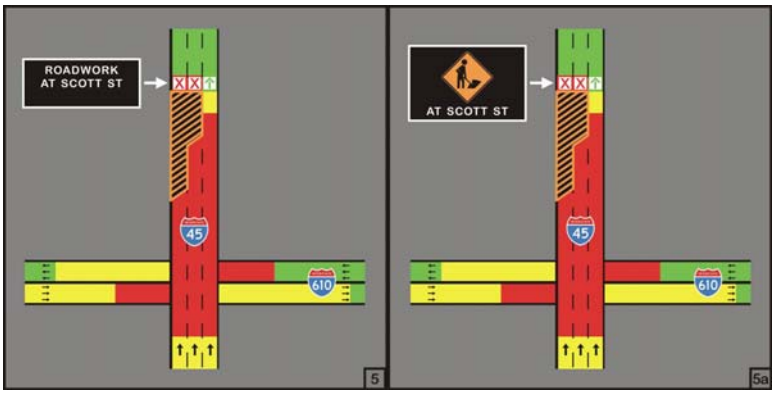


Figure 22. Signs 5 and 5a – Work Zone Text versus Work Zone Symbol.

Researchers were interested in determining how drivers would change their decisions and reactions based on the fact that the cross highway shown in a graphic was a toll facility. Figure 23 shows the two signs that were used to determine if drivers could identify a cross highway as a toll facility and if that would affect their alternate route choice. A no-toll scenario was also introduced to the participants to determine how this operational change would affect drivers' alternate route selection.

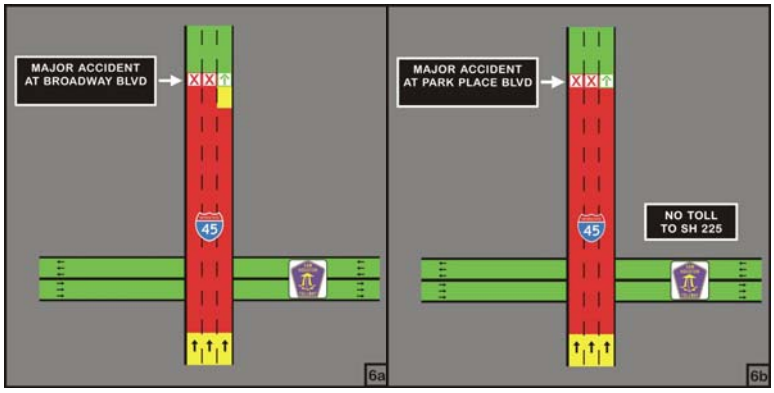


Figure 23. Cross Highway Toll Road Signs.

Researchers also evaluated each of the signs presented in Figure 13 for participant understanding of the red/yellow/green color-coding system that was intended to represent congestion levels or speed. This evaluation was conducted throughout the study to determine how changing graphics and features affected this understanding. More specifically for this section of the study, researchers evaluated the impact of including a small yellow area near the accident to imply that traffic is moving in that area to determine how this would impact driving decisions and comprehension. A preference comparison was also done using the signs shown in Figure 24. In addition, a comparison was conducted of four different options (Figure 25) of color coding to indicate that the right lane was open but congested.

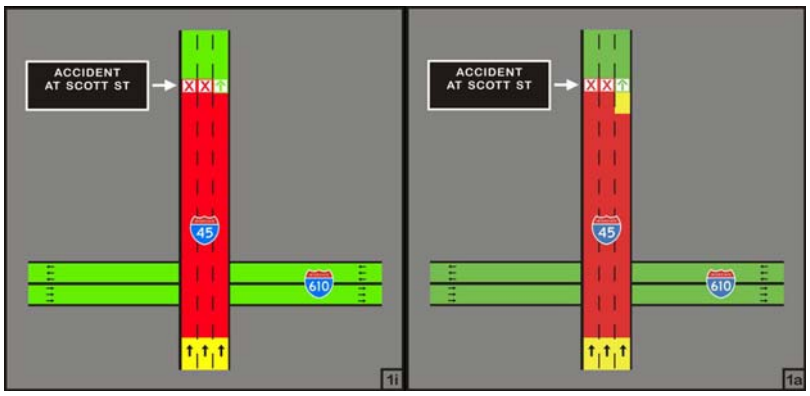


Figure 24. Signs 1i and 1a – No Yellow Box versus Yellow Box in Open Lane.

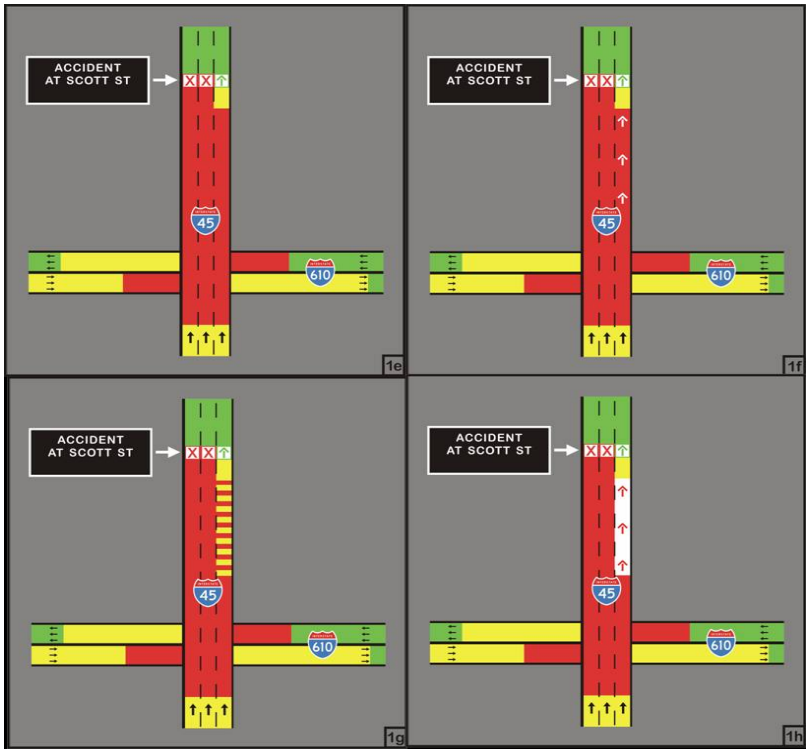


Figure 25. Signs 1e, 1f, 1g, and 1h – Different Right Lane Open Options.

Topic Area 2: GRIP

For this topic, researchers determined if the participants could identify the congestion, accident, and its location when displayed in a GRIP design. For this portion of the study, two different formats were evaluated. Figure 26 shows these formats. The first format represents a full view of a metropolitan area while the second represents only a portion of that area. Researchers wanted to investigate how this change would impact comprehension as well as viewing time to determine the one most appropriate for use.

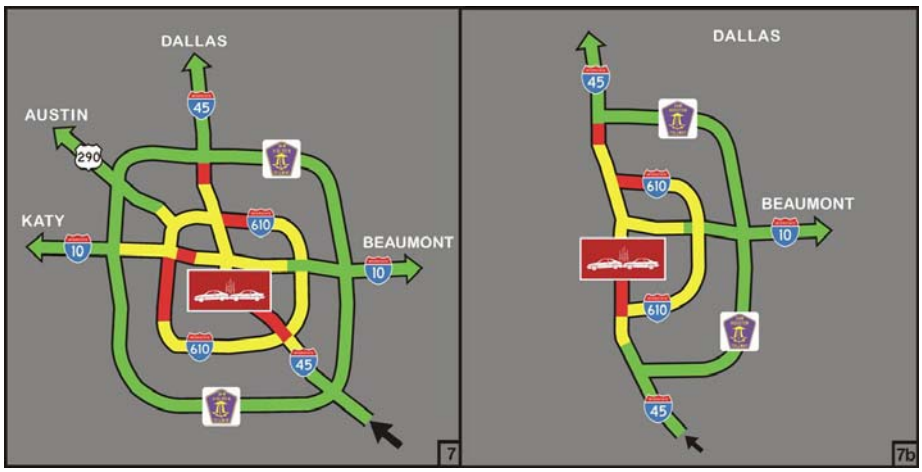


Figure 26. GRIP Full Area versus Half Area View.

Topic Area 3: High Occupancy Vehicle Lane Identification

The next topic in the study was used to determine the ability of participants to identify an HOV lane that was depicted on a graphic sign. Researchers introduced a situation for this section where the local area was under an emergency evacuation. Based on these conditions, researchers evaluated how participants would interpret the inclusion of text that the HOV lane was open to all traffic. Figure 27 shows the graphic used for comprehension analysis.

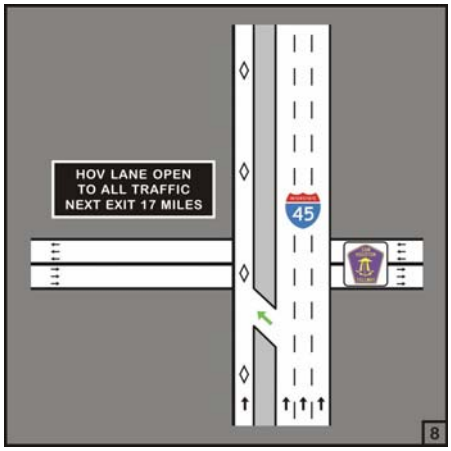


Figure 27. HOV Lane Open to all Traffic.

Additionally, within this topic participants were asked to compare the images shown in Figure 28 as to their preference for the information provided in the text box. This comparison included the difference in wording between “Next Exit 17 Miles” and “No Exit 17 Miles” and the inclusion of a diamond symbol in the text box to assist in the identification of the HOV lane.

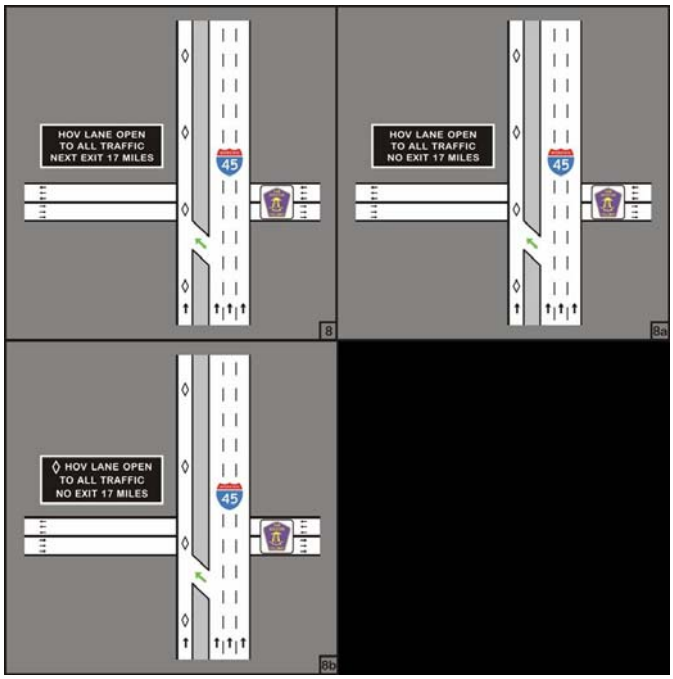


Figure 28. Terms for No Exit for Next 17 Miles and HOV Symbol.

Topic Area 4: Adjacent Toll Lanes

Within this topic area, researchers introduced roadway geometry into the graphic that was unfamiliar to the study participants. Figure 29 shows the initial graphic used in this section. Researchers wanted to investigate the ability of the participants to identify the separated set of lanes on the left side of each graphic as a portion of the facility traveling in their direction and for them to identify it as a restricted toll facility. Additionally, researchers queried participants as to their interpretation of the "TxTag" symbol within this graphic.

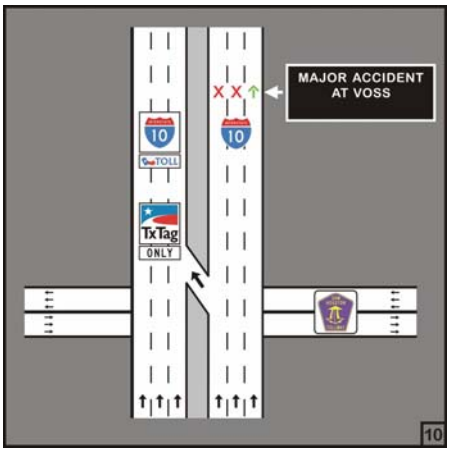


Figure 29. Adjacent Toll Lanes.

As with the previous toll road scenarios, researchers introduced a suspended toll collection situation, as represented in Figure 30, to determine if participants could understand what the "no toll" information meant with regard to facility use and to identify how this condition would change their travel decisions.

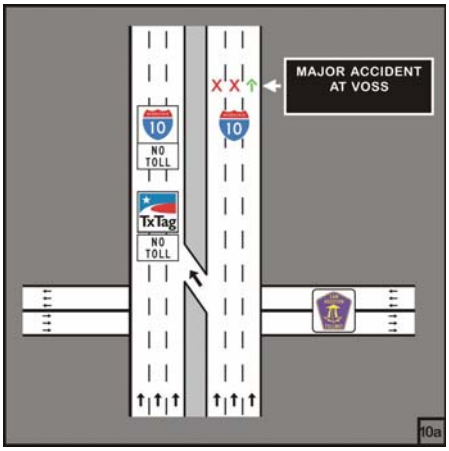


Figure 30. Adjacent Toll Lanes – Suspended Toll Condition.

Finally, researchers showed three graphics for comparison, as depicted in Figure 31. In this case, researchers wanted to identify participants' preference for different wording and symbols to represent a toll suspension condition. The three alternatives evaluated included "No Toll," "Free" with a TxTag symbol, and "Free" without a TxTag symbol.

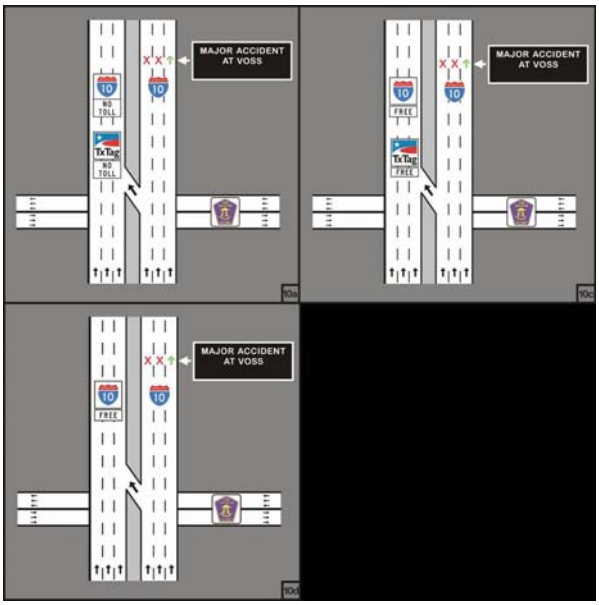


Figure 31. Preference on Terms for Suspension of Toll.

Topic Area 5: Truck Route

The final topic of interest for this study evaluated graphics that could be used to identify an optional truck route that would be available to bypass a major metropolitan area. Figure 32 shows this image. The primary focus of this section was to obtain the input of large-truck drivers with regard to their interpretations and decisions. Once again, colors were used to depict congestion levels on the illustrated roadways and to determine how drivers would react based on the congestion shown.

Figure 32. Optional Truck Route.

Three sets of comparisons were conducted to evaluate participant preference for different features of the truck route graphics. In the first comparison researchers evaluated three different terms to determine which would best indicate to a driver that this is an optional route that drivers could use to bypass a particular area. Figure 33 illustrates the images, which used the terms "Truck Route," "Best Route," and "Bypass." Next, researchers investigated the participants' preference for including a truck icon on all or only some of the segments of a given alternate route. Figure 34 shows the options used. Lastly, researchers identified what information was important with regard to travel time or congestion indication when making route decisions. Figure 35 shows three options that were evaluated for different combinations of this information.

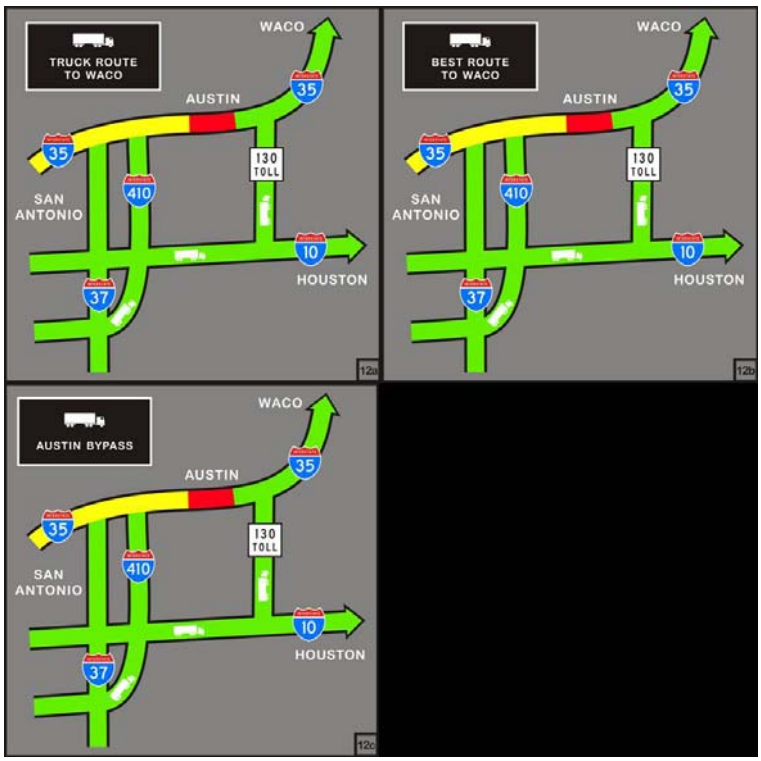


Figure 33. Terms to Encourage Truck Drivers to Divert to the Optional Truck Route.

Figure 34. Placement of Truck Icons on Segments of the Route.

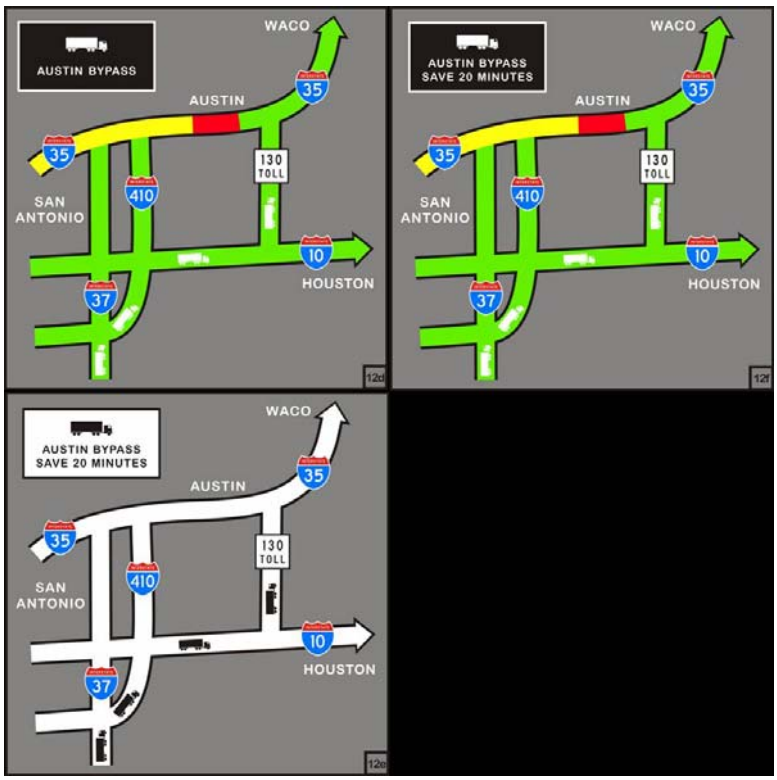


Figure 35. Travel Time and Congestion Information.

Laboratory Instruments

The laboratory instrument developed for this study was divided into separate sections, each addressing a specific topic. To avoid the occurrence of primacy bias, the order of the graphic message displays was interchanged in four different surveys. Appendix B contains an example of the study instrument.

Study Locations

The study was conducted in the same five Texas cities that were used in the focus groups: Brownsville, Dallas, El Paso, Houston, and San Antonio. The lab study was held at TTI facilities in Dallas, Houston, and San Antonio; while the El Paso study was held in a hotel meeting room. The Brownsville study was conducted at a truck stop in order to target the recruitment of semi-truck drivers involved with long-haul operations in the demographic sample.

Participant Recruitment

There were 160 individuals that participated in this study, with 32 from each of the five study locations. Participants were recruited from the TTI participant pool list and public notices that were posted and distributed at local businesses, agencies, senior centers, etc. Drivers of large semi-trucks were recruited at a truck stop between Brownsville and San Antonio to help ensure recruiting long-haul truck drivers who frequently traveled along this corridor. This recruitment was done via individual contacts to participants by researchers.

Demographics

The criteria that were used to recruit general drivers for the study were to have a current Texas driver's license, to be over the age of 18, and to travel at least 8000 miles per year. The latter criterion was used to ensure that the participants were frequent drivers and familiar with the roadway system and with DMSs. As in the focus groups, the researchers' goal was to recruit a sample of drivers based on the demographics of the driving population of Texas with regard to gender, age, and educational level. The statistics utilized for age and gender were obtained from the United States Department of Transportation – Federal Highway Administration Statistics for 2003. The education level statistics were based on Texas information from the United States Census Bureau for the year 2003. Gender and education statistics indicate an even split of male versus female drivers as well as those with a high school diploma or less versus some college to a college degree. Table 4 shows the demographic sample obtained and needed based on cross-referencing the gender, age, and education level of the Texas population. The numbers in italics represent the sample population obtained. As shown in Table 4, the actual sample very closely matched the age demographics established for the study. Additionally, there were adequate numbers of gender and education levels obtained overall, although the numbers were slightly shifted as to which cell of the table they fell into with slightly more males in the high school diploma category or less and slightly more females in the some college + category.

Table 4. Demographic Sample for Primary Level 1 Laboratory Study.

Age	Education Level				Total (n=128)	
	High School Diploma or Less (50%)		Some College + (50%)			
	Male (25%)	Female (25%)	Male (25%)	Female (25%)	Numbers	Percentages
<25	(4.5) *3*	(4.5) *5*	(4.5) *4*	(4.5) *8*	(18) *20*	(14) *16*
25-54	(19.25) *24*	(19.25) *16*	(19.25) *16*	(19.25) *20*	(77) *76*	(60) *59*
54+	(8.25) *7*	(8.25) *9*	(8.25) *8*	(8.25) *8*	(33) *32*	(26) *25*
Total	(32) *34*	(32) *30*	(32) *28*	(32) *36*	128 *(128)*	100

NOTE: Numbers in italics represent the sample population obtained.

The 32 truck drivers recruited in Brownsville for this study were not included in the above demographic table. As expected, the majority of these participants were male (94 percent), with a little less than 60 percent having a high school diploma or less and about 40 percent with some college or more. The younger age category had the most participants (43 percent), and the older category had the least number of participants (22 percent). The remaining 35 percent fell in the middle age category of 25 – 54 years. In this sample researchers felt it was more important to get a diverse range of the driving experience for the truck driver participants than to match the Texas demographics of the average driving public. To determine this, each truck driver participant was asked how many years they had been driving a semi-truck. The most inexperienced truck drivers (<5 years) represented 22 percent of our sample population. The drivers with 5 to 10 years experience consisted of 30 percent of the sample and those with 11 to 20 years experience represented 33 percent. The remaining 15 percent of our sample consisted of drivers with more than 20 years driving experience.

Study Protocol

Upon arrival, participants were provided with a brief explanation of the study and asked to read and sign an informed consent document. Demographic characteristics (age, gender, and education) were recorded for future reference. Researchers explained to participants that the survey was looking toward the future with the development of large full-color dynamic message signs that were similar to the large scoreboards they usually saw at major sporting events. They were also told that there would be a very small number of these large signs used in any one city, and that transportation professionals anticipated that these signs would be installed near major

freeway-to-freeway interchanges. This explanation was provided so that participants would have a better idea from the beginning of what to expect within the study content.

Prior to each section in the survey, participants were given a map to review of the major roads in the selected metropolitan area of their study city. Researchers explained to each participant their beginning location, their destination, and which cardinal direction they should travel to reach their new destination for the hypothetical driving situation. They were told to take their time looking at the map and when they were familiar with the route they would take to let the researcher know. After reviewing the map, the participants were asked which route they would take to clearly establish their anticipated path.

Researchers explained to participants that they would view a series signs one at a time that would display different types of information. As such, when they pressed the space bar on the keyboard the first graphical message sign would appear on the laptop monitor screen, and they would have complete control over how long they viewed each sign. So, the instant they had read the message they needed to press the space bar once to turn the message off. At that point the researcher would ask questions about the information displayed on the sign. Following the self-paced comprehension study, most sections had a comparison portion of the study to determine drivers' preference of certain elements or terms and why they preferred the options they selected. During this part of the study, researchers indicated to the participants that the sign would stay on the screen until all they had completed asking questions.

GRAPHIC INTERCHANGE INFORMATION

As discussed in the study design, there were six primary signs that participants evaluated for comprehension in this topic area of the human factors study. These signs were shown in Figure 13 and were designed to specifically compare drivers' understanding and decision making based on the different elements that were included on the graphics. Also included in this section of the analysis were the signs that were evaluated with regard to driving decisions when the cross highway is a toll road (Figure 23). The sections below illustrate how the different graphic elements impacted driver understanding and decision making.

Accident Symbol versus Text

The first set of graphics addressed evaluated the difference between the use of a symbol to represent a vehicle accident versus using the text "accident." Additionally, the coloring of the symbol was red based on focus group input that this color would imply a major accident to drivers. The results revealed that 92 percent of participants understood the symbol to mean an accident; however, they did not interpret the red as providing information regarding accident severity (i.e., that the accident was major) but interpreted the content of the symbol (i.e., the depiction of a rear-end collision) as implying a minor accident. Table 5 shows the participants' identification of accident severity for each sign evaluated.

Table 5. Percentage of Participants Indicating Accident Severity.

Responses	Percent (%)					
	Sign 1a (n=160)	Sign 1d (n=160)	Sign 1e (n=160)	Sign 1i (n=160)	Sign 3 (n=160)	Sign 4a (n=160)
Major	76	56	79	77	82	81
Minor	20	42	17	20	15	16
Don't Know	4	2	4	3	3	3

As researchers evaluated the identification of severity, results revealed that the participants were split almost evenly as to it being a major or minor accident when the symbol was used (Sign 1d); whereas with the text version of "accident," greater than 75 percent assumed it was a major accident for all of the other graphics. The follow-up questioning conducted by researchers showed that in the absence of the symbol the participants based their decision of severity on the fact that two lanes were closed.

However, with a direct preference comparison of the two versions (text versus symbol) the participants mostly preferred the symbol version of this sign. They stated that it gave a better visual or showed what had happened in the accident. This answer would imply that the driver relies heavily on the content of this symbol to provide them with accident information.

Researchers also asked participants to evaluate two different colors of the symbol, red and yellow, in a side-by-side comparison to determine if they had different meanings to the driver. Eighty-three percent of the participants believed that the color change gave them different information, and the majority of these people believed that the red indicated major and

the yellow indicated minor accidents. Nevertheless, the comprehension data for the red symbol does not support this trend as the majority of participants did not identify this as a major accident. Again, in the case where red was used alone (i.e., not shown next to a yellow symbol) the participants did not derive their understanding of major from the color but looked at the content of the symbol (a simple rear-end accident) to determine that the accident was not severe. In this case, researchers believe that more work is needed in the second human factors study to determine how the accident symbol should appear so as not to mislead the driver regarding the accident. Several suggestions were made during the comparison as to how to make the symbol represent major or minor. The most common response was to include text of either "major" or "minor" on the sign. Also, they believed that for a major accident the graphic should show more vehicle damage.

A final analysis that was conducted for the accident symbol was to present four different symbols on the screen and ask participants to define what each symbol meant to them and which would best indicate an accident. Figure 16 shows these symbols. For each of the first three symbols, the majority of participants (94, 96, and 93 percent, respectively) believed that the symbol indicated an overturned car. In the case of C-2, 84 percent believed that the car was also on fire. However, for symbol C-4, 63 percent stated that it was an accident or rear-end accident, with an additional 26 percent indicating it was an accident with fire. Given these interpretations, 89 percent of the participants selected C-4 as the best symbol to use to represent an accident. They believed that the use of multiple vehicles made it easier to understand and that this was a familiar image. When asked if they would change anything to indicate a major accident, the primary suggestions offered were to add text "major," have more vehicle damage to C-4, or to add red color to the symbol.

Given all of these variances in symbol interpretation, researchers included more analysis of accident symbol design and use in the second set of human factors studies to identify that the symbol is as effective as a text option and to address the question of accident severity through the use of variations to the accident symbol.

Arrow versus No Arrow in Open Lane

The next element evaluated was the inclusion of an arrow in the open lane of the roadway. All but one of the signs (Sign 1d) included an arrow to indicate that the far right lane

was open for traffic. Based on data analysis, researchers determined that there was no difference in the identification of the open lane based on the presence (or absence) of the arrow. Table 6 shows the percentage of participants who correctly identified which lanes were closed for each of the evaluated signs.

Table 6. Percentage of Participants Indicating Lane Closure.

Responses	Percent (%)					
	Sign 1a (n=160)	Sign 1d (n=160)	Sign 1e (n=160)	Sign 1i (n=160)	Sign 3 (n=160)	Sign 4a (n=160)
Correct Lane Closure	89	88	86	86	89	86
All Closed	11	12	13	14	9	14
All Open					2	
Other			1			

In all cases, the participants identified the accurate lane closure 86 – 89 percent of the time. This percentage implies that the arrow is not necessary for understanding. However, in a preference comparison of these two options, the participants overwhelmingly (94 percent) preferred including the arrow in the open lane. They believed that it gave a better impression of the lane being open and moving past the accident. Several participants also stated that it provided them with a clearer image of what lane they should use. Researchers would recommend the inclusion of an arrow in the open lane(s) based on this preference and the fact that the inclusion of the arrow did not negatively impact driver understanding.

Sequential Arrows in Open Lane

Researchers created an alternative design for consideration in the preference section of the study that showed a sequence of arrows in the right lane to imply to drivers that this is the lane to use if they decide to stay on the freeway past the accident (Figure 17). This alternative graphic was shown along with an identical design that did not have the arrows. In this case, 96 percent of the participants believed that the sign with sequential arrows provided them with more information. The highest percentage of these participants stated that it showed them the lane to use or that was open (54 percent). However, 30 percent believed that the sequential arrows indicated that the right lane was moving. Researchers are concerned that this interpretation

could reduce the credibility of the sign as drivers would expect movement in the right lane, which is not the case based on the identified traffic conditions (red). Given the extra information load inherent with the addition of the sequential arrows, researchers would not recommend their use as it did not significantly improve the understanding of drivers regarding the open lane.

Congested Cross Highway

One of the primary purposes for using a graphic display for an incident situation is to provide drivers with more information regarding location and alternate route options. Based on this, researchers were interested in whether the introduction of different congestion levels on the cross highway would affect driving decisions. Researchers found that when traffic congestion was illustrated on the cross highway near the interchange, there was a slight increase in the percent of participants who stated that they would stay on the original highway versus selecting an alternate route. Table 7 shows the different route selections for each sign. Note that the signs that showed congestion on the cross highway were Signs 1e, 3, and 4a.

Table 7. Percentage of Route Selection.

Responses	Percent (%)					
	Sign 1a (n=160)	Sign 1d (n=160)	Sign 1e (n=160)	Sign 1i (n=160)	Sign 3 (n=160)	Sign 4a (n=160)
Stay on freeway	19	26	26	12	13	16
Take Cross freeway	59	56	49	62	53	64
Take Local Streets	11	6	12	12	18	8
Take Frontage Road	8	8	8	11	10	8
Other Familiar freeway	3	4	5	3	6	4

Researchers made a direct comparison between Signs 1a (uncongested cross freeway) and 1e (congested cross freeway) as all other elements on these signs were the same. As illustrated in the table, 26 percent stated they would stay on the original highway for Sign 1e which did have congestion on the cross highway versus only 19 percent for Sign 1a which did not have congestion. However, when researchers compared Sign 1e (congested cross freeway) to Sign 1d (uncongested cross freeway, accident symbol) the percentages were the same for

staying on the freeway. Researchers noted that in the reasons given by participants for staying on the freeway for Sign 1d there was a significant number of participants who stated they would stay because it was a minor accident only. In the case of Sign 1e, the reasons for staying were given as it was a direct route or that the cross highway was congested. These responses imply that the interpretation of the accident severity has a significant impact upon driving decisions along with the congestion indications.

Three-Dimensional Perspective

Sign 4 was created to provide the drivers with a more accurate perspective of the roadway as compared to the other signs that showed a plan view. Researchers determined the difference in drivers' ability to understand the information provided in the graphic. Researchers determined that the perspective view of the accident area did not impact the participants' ability to understand the sign and the information regarding the accident. However, researchers found that there was a significant increase in the amount of time that the participants viewed this sign that would imply the change of perspective was an additional information load for the participants. In this case the average viewing time was 32 seconds as compared to Sign 1e (which contains similar information but in plan view and without ramps) that was viewed for an average of 21 seconds.

When participants were shown a side-by-side comparison of the plan view versus a three-dimensional perspective (Figure 18), the majority (83 percent) preferred the perspective view. The participants stated that they liked the perspective as it showed the overpass or gave details regarding the area. However, given the extra time that it took participants to understand this option during the comprehension portion of the study, researchers would not suggest its use based on preference alone as the change did not significantly enhance the participant's understanding of the scenario.

Ramps

Also included on Sign 4 were connector ramps to show the direct connect segments at the freeway interchange. Eighty-eight percent of the participants identified these segments as interchange ramps. This comprehension level is sufficient to indicate that the inclusion of ramps as shown would be acceptable on the graphics. However, the increased driver information load

inherent with the inclusion of the ramps may not be necessary as most people were able to identify that they could exit to the cross highway without having ramps shown on the graphic (see Table 7 regarding alternate route selection). The inclusion of these connectors also adds a level of difficulty in sign development as they would need to be physically accurate (e.g., if there is a left exit this would need to be illustrated) for a driver to feel confident in making driving decisions based on the image. One point of interest with regard to alternate route decisions is that the addition of the ramps as they were shown aided participants in identifying that the congestion area shown at the interchange would not affect the use of the cross freeway, but that they would enter the highway beyond this congestion. This additional congestion identification was used by many participants in their decision to use the cross freeway as compared to Sign 1e (no ramps) where they saw the changing of freeways as leading them into the congestion.

In the comparisons portion of this survey, participants were asked to compare two signs, both in the standard plan view, where one showed exit ramps and the other did not. Eighty-nine percent of the participants preferred the view that showed the ramps for this question. They indicated that showing these ramps gave them an alternate route to take around the accident or simply showed an available exit to consider.

Cross Streets

Sign 3 was designed to show all of the major cross streets available between the upcoming freeway interchange and the accident location. Researchers wanted to identify if this information would help drivers in identifying more accurately the accident location and available alternate routes to use. When this information was included versus providing the accident location via a standard line of text (e.g., “at Geronimo Dr.”) there was a negative impact on the participants’ understanding of the accident location. Table 8 shows the percentage of participants who correctly identified the accident location for each of the signs.

When cross streets were provided graphically (Sign 3), only 64 percent correctly identified the location as compared to Sign 1e (same in all elements except cross streets) which had 93 percent of the participants correctly identify the cross street where the accident was located. Also, all of the text-based location identifiers were understood at a level greater than 80 percent of participants.

Table 8. Percentage of Participants Identifying Accident Location.

Responses	Percent (%)					
	Sign 1a (n=160)	Sign 1d (n=160)	Sign 1e (n=160)	Sign 1i (n=160)	Sign 3 (n=160)	Sign 4a (n=160)
Correct Location	96	83	93	93	64	89
Wrong Street Identified	1	4	3	2	28	3
At All Shown Streets					1	
Don't know	3	13	4	5	7	8

In addition, the viewing time for Sign 3 increased due to the increased information load presented. The average viewing time for Sign 3 was 28 seconds compared to 23 seconds for Sign 1e. These two results taken together imply that graphic designs should not use graphic cross streets to increase participant understanding of location. However, one positive impact that the addition of cross streets created was that it helped the driver to identify the availability of different alternative routes in the immediate area of the accident and encouraged them to use these routes as opposed to staying on the highway or using the cross highway as a means around the area. This impact was illustrated through their alternate route selection where there were an increased number of participants who stated they would use one of these local streets as an alternate route around the accident (see Table 7).

In the comparisons section, researchers evaluated sign options that included four cross streets versus only one cross street to identify accident location. In this situation, 78 percent of the participants preferred to see multiple cross streets. They believed that it helped them to identify more options for alternate routes near the accident (as shown during the comprehension portion of the study in route selection). Of the people who preferred the single street they stated that the multiple streets gave too much information to the driver. This overload of information is illustrated through the added viewing time needed for Sign 3 in the comprehension section.

The final preference comparison done for this section was of the image that used a single cross street as a means of identifying the location of the accident versus a standard text-based location. In this case, 73 percent preferred the text version of the sign stating that it gave the specific location or that all of the information was provided in the same place on the sign. For the participants who did prefer the graphic representation of the street, they believed that it showed a better idea of exactly where the accident occurred. The preference for text-based representation along with the higher viewing time and lower understanding as described above

leads researchers to not recommend using the graphic representation of the local cross streets to enhance accident location information.

Work Zone

In the final preference comparison researchers evaluated the use of a symbol versus text to indicate roadwork as well as looking at driver understanding of a graphical representation of a lane closure (Figure 22). In this situation, 98 percent of the participants stated that the black and orange area on the road represented the area blocked by roadwork and that the symbol used in Sign 5a indicated roadwork. This high level of comprehension indicates that the use of these information elements would be well understood by drivers and appropriate for use on this type of sign.

When asked which they preferred for this scenario, text or a symbol for roadwork, 84 percent of participants indicated that they liked the symbol. This was the same as was determined for the use of an accident symbol indicating that if symbols are well understood, they will be well received by the public for use on signs. In this case, the participants stated their reasons for preferring the symbol sign is that it was familiar or there was less text for the driver to read. Finally, researchers asked participants if they would change anything about the sign. There were a variety of suggestions; however, one suggestion that was commonly repeated was to include both the symbol and "roadwork" on the sign to ensure understanding of all drivers. Another suggestion that caught the attention of researchers was to indicate the number of miles under construction.

Given that this information was only evaluated in a side-by-side comparison for this first interpretation, researchers will include it in the second set of human factors studies to further evaluate comprehension and viewing time of this information.

Cross Highway Toll Road

Signs were also evaluated that had a toll road as the cross highway. In this case, all of the information was the same as Sign 1a except the toll road as a cross highway. This change was incorporated to determine the drivers' ability to identify the roadway as a toll road from the highway shield alone and to compare drivers' willingness to detour to a tolled facility. When questioned, 91 percent of the participants identified that the cross highway was a toll road. This percentage shows very good understanding of the highway shields used for this purpose. One

important note is that the Houston and Dallas signs used shields that were familiar and currently in use (i.e., the Sam Houston Tollway and Dallas North Tollway signs) but that the other three locations used the toll road shield as illustrated in Section 2J, Figure 2J-1 of the TMUTCD (*41*). For reference, Table 9 shows the individual location comprehensions for Sign 6a with regard to the cross highway being a toll road. It should be noted that the addition of the toll information did not increase the average viewing time for each message.

Table 9. Percentage of Participants Identifying Toll Facility.

Responses	Percent (%)					
	Brownsville (n=32)	**Dallas (n=32)**	**El Paso (n=32)**	**Houston (n=32)**	**San Antonio (n=32)**	**Overall (n=160)**
Correctly Identified Toll Facility	84	94	97	91	91	91
Did Not Recognize Toll Facility	16	6	3	9	9	9

With regard to alternate route selection, there was a drop in the percent of drivers who would take the cross highway, from 59 percent for Sign 1a (non-toll cross highway) to 53 percent when it was a toll facility; however, this difference was not statistically significant based on a test of proportions. Researchers note that when the second sign in this grouping provided information that the toll was waived for a specific portion of the toll road, the percentage of participants indicating they would take the cross highway increased to 63 percent, identifying that the presence of a toll on the cross highway does have an impact on driving decisions.

As mentioned, the second sign in this grouping was an indication that there would be no toll on the toll road to a specific location along this route (e.g., “no toll to Loop 375”). In this case, 79 percent of the people understood that they would not have to pay to use the toll road. Although this is lower than hoped, it is still acceptable for use and not an unexpected result as this type of condition is very unusual and therefore not expected by the driver. Finally, researchers wanted to identify if the participant was able to understand where the no toll area would end based on the information provided. Analysis shows that only 69 percent of those who understood that there was no toll could also identify the location where this condition would end. That would mean only 54 percent of the total participants would fully understand the information

provided. For this scenario, researchers recommend considering other forms of information such as miles or exit number/name to better identify the end point. As with all exit or location information used on DMSs the preference of drivers for names versus distance or exit numbers depends highly on the familiarity of a driver with the given area.

Color Analysis

One of the primary features of the graphics used in the majority of this study was the use of a green/yellow/red color-coding system to provide information to drivers regarding travel conditions or congestion. Researchers asked the participants to identify what the colors would mean to them for each of the signs. Table 10 shows the comprehension percentage for each of the different signs included in this analysis. The table includes further information regarding the red color interpretation (as opposed to green or yellow) as this was the point that most people misinterpreted and therefore skewed their overall understanding of the color coding. It should be noted that the first six signs in the table are the signs discussed in this section of the report. The final two signs are from subsequent topic areas and are of a GRIP format that shows the area network of highways.

Table 10. Participant Interpretation of Color Coding.

Interpretation	Percent (%)							
	Sign 1a (n=160)	Sign 1d (n=160)	Sign 1e (n=160)	Sign 1i (n=160)	Sign 3 (n=160)	Sign 4a (n=160)	Sign 7 (n=160)	Sign 12 (n=160)
Correct	72	77	76	68	70	78	84	81
Closed/Open	17	14	14	19	16	13	6	5
Red – Danger	4	3	3	4	4	3	4	3
Red – Accident	1	2	3	3	2	1	2	3
Other	6	4	4	6	8	5	4	8

Researchers identified no significant difference between the percentages of participants who understood the colors based on the different graphic layouts. For all of the signs, participants' comprehension levels were between 68 and 84 percent. These percentages imply that the majority of drivers understood the colors as they were used. Of the people who did not understand, the primary incorrect interpretation was that the colors were implying a closed (red)/open (green) situation for the lanes. This was stated by between 13 and 19 percent of the

participants for the group of signs discussed in this section. The concern with this interpretation is that if drivers do not understand the color meaning, they may make decisions regarding taking alternate routes based on incorrect assumptions. This action can lead to credibility and effectiveness issues for the graphics overall as drivers will not understand or believe the information provided and make poor driving decisions. Researchers noted that this misinterpretation was reduced when evaluating the GRIP format signs.

Yellow Indication near Accident Location

In evaluating how much detail with regard to congestion levels the participants were using in their decision making, researchers wanted to know if the inclusion of a small yellow (or slowly moving area) near the incident area would change driver behavior or understanding. Based on responses to a series of questions related to the movement of the right lane and route choice, researchers determined that the presence or absence of the small yellow area did not have an impact on the participants understanding that the right lane was open. As Table 6 illustrates, there was no change in the participants' understanding of which lanes were open for Sign 1i which did not include the yellow area near the accident location.

Furthermore, the inclusion of the yellow area in the right lane did not have a significant impact on participant understanding of the fact that the right lane was moving slowly or was stop and go traffic in this area. Table 11 shows the participants' interpretation of how the right lane would be moving.

Table 11. Percentage of Participants Identifying Different Movement in the Right Lane.

Responses	Percent (%)					
	Sign 1a (n=160)	Sign 1d (n=160)	Sign 1e (n=160)	Sign 1i (n=160)	Sign 3 (n=160)	Sign 4a (n=160)
Slow	90	83	89	85	91	89
Stop	8	11	10	13	6	9
Good/Normal	2	6	1	2	3	2

In all cases, better than 90 percent of the participants said that the traffic was moving slowly or stopped. The percent of participants that indicated the lane was stopped for Sign 1i,

which did not have the yellow area, showed only a slight increase; however, this was not a statistically significant increase based on a test of proportions.

In a preference comparison of this element, the majority of the participants preferred the image that included the yellow area near the accident. These participants interpreted this element to mean that the traffic was regaining speed near the accident. However, there was a small percentage of participants that believed the absence of the yellow area implied that there was no need to use caution in this area (13 percent) and thereby interpreted this graphic to mean that traffic would move better near the accident without the yellow. When asked which sign better showed that the right lane was open for use, 88 percent believed that the sign with the yellow area included was the better sign. The participants stated that they preferred this sign because it gave them the impression of moving traffic near the accident (58 percent) or that it was showing you the lane to use or that was open (16 percent).

Researchers also did a comparison of different options of color coding for the right lane that would imply that the lane was open but congested. There were four graphics used in this comparison: 1e, 1f, 1g, and 1h. Table 12 shows the percentage of participants preferring each option.

Table 12. Percentage of Participants Preferring Right Lane Option.

Sign Number	Percent Preference
1e	5
1f	29
1g	13
1h	53

As the table illustrates, the greatest percentage (53 percent) preferred Sign 1h that showed the right lane as white with red arrows. However, this preference was based on the fact that they believed the white implied that there was no traffic congestion in this lane. Therefore, the alternative displayed in Sign 1h would not be appropriate for use as it does not provide an accurate impression of the congestion conditions. Of the other three options, Sign 1f was the next most preferred (29 percent). The participants stated that they liked this option because it was simpler and showed what lane to use or that the lane was moving. Again, this interpretation is not completely accurate for the conditions; however, it was more accurate than 1h. Although people did understand 1e, they liked the added detail of the later signs (arrows or colors) and therefore did not select this as their preference. With Sign 1g, the use of alternating color bars of

red and yellow was understood as stop and go traffic by only 48 percent of the participants and therefore is not recommended for use. From this analysis, although the participants did not prefer the option of 1e, it did show the best understanding of conditions for the given scenario and would therefore be the most appropriate to use.

Other Information Suggestions

For each of the signs evaluated in the comprehension portion of this study, researchers asked the participants to identify other information they would like to see included on the signs. There were two items that were very commonly indicated for all of the signs. These were travel or delay time due to the accident and providing drivers with a suggested alternate route. Other items that were suggested included (but were not limited to): exits to use, severity of accident, and other construction or accidents. The project team has already discussed the inclusion of travel times on graphics for the next phases of the human factors studies and the researchers will develop information to this end in the study design.

GRIP ANALYSIS

The next topic area of the study included two images that were graphical representations of the highways for a metropolitan area (Figure 26). The first one was a full network of major highways, while the second graphic only showed half of the area (e.g., only the east half of the graphic). From this information researchers wanted to determine if the participants could use the information provided to identify the accident and its location and to make route decisions.

In comparing the two views provided to the participants, results show that the inclusion of a full or only half view had very little effect on the answers given by the participants. In both cases, 68 percent of the participants were able to identify the location of the accident. This similarity illustrates that driver comprehension was not adversely impacted by providing only a partial view of the area network. Additionally, the route decisions given based on the signs were not changed based on the different graphics. In both cases, just over 70 percent (73 and 72 percent, respectively) of the participants indicated they would take the alternate route that was anticipated by researchers. The route varied for each city based on the accident location selected; however, in most cases it was a loop highway or another easily identified major freeway route past the accident.

One question that was only asked for the full view sign was to identify the severity of the accident. Again, researchers wanted to gauge the interpretation of participants of the coloring and content of the accident symbol. Table 13 shows the severity identified by the participants.

Table 13. Percentage of Participants Identifying Accident Severity.

Severity	Percent (%)
Major	76
Minor	16
Don't Know	8

When this severity identification is compared to the information gathered in the first section of the study (see Table 5) there was a significant difference in the participants' responses in this section than when the red symbol was used in Sign 1d. Researchers attribute this difference to the additional preference discussions that were conducted following the initial interpretation of Sign 1d wherein the participants viewed both red and yellow signs to identify if there was a difference in the information provided. From this discussion, the participants may have formed new opinions as to the meaning of the color included with the symbol. Another thought is that the participants' familiarity with the symbol increased after viewing it several times and they are no longer giving the content of the symbol as much consideration as during the first viewing. Again, further study is needed to determine how the inclusion of symbols and the severity of accidents can be addressed within graphical messages.

Researchers also reviewed the viewing time information for each sign to see if the time needed to interpret and comprehend the GRIP format was significantly less for either the full or half view sign options. Researchers found that for the full view sign the average viewing time was 24 seconds and for the half view sign it was 22 seconds. Although it was lower for the half view sign, it was not a significant difference in the timing. This similarity in viewing times implies that the change in the graphic did not significantly reduce the workload for participants.

Participants were again asked to provide comments as to what further information they would like to see on the sign. Participants again indicated that they would like to see travel time or delay information on the sign (15 and 18 percent, respectively) and that they would like the sign to provide them with a specific alternate route (27 and 26 percent, respectively).

The final information gathered from this section was to identify the participant preference for one sign format or the other. Table 14 shows the percentage of participants preferring each sign option.

Table 14. Percentage of Participants Preferring Each GRIP Option.

Sign Option	Percent (%)
Sign 7 – Full View	58
Sign 7b – Half View	43

As the table illustrates, there was a slight preference for the full view sign. The participants stated their reasons for this preference as the full view sign gives more route options or more information about the area. Conversely, the participants who preferred the half view sign liked that it was simpler and did not provide as much information, making it easier to read. This analysis indicates that either form of this sign is acceptable for use depending on the accident location and necessity of drivers' ability to view different portions of the area.

HOV LANE IDENTIFICATION

The intention of the HOV Lane graphic evaluation was to determine if participants could easily recognize that the separated lane represented an available travel lane in their direction, and that operations for the HOV lane had been changed due to an emergency situation (in this case an evacuation due to a hurricane). Participants were initially shown the graphic in Figure 27 and asked a series of questions that evaluated both their interpretation of the information and their reaction to the information. From this analysis, researchers noted that participants' local knowledge of HOV lanes heavily influenced their ability to identify the function of the separated lane. In other words, in San Antonio and El Paso where there is not currently an HOV system in place, the understanding was lower than in Houston and Dallas. Brownsville participants were all truck drivers that travel throughout the state and therefore were much more knowledgeable even though they did not locally have HOV lanes. That being said, Table 15 shows the interpretation of the participants separated by location as to what information they believed the sign was giving them.

Table 15. Information Participants Gained from the Sign.

Responses	Percent (%)					
	Brownsville (n=32)	Dallas (n=32)	El Paso (n=32)	Houston (n=32)	San Antonio (n=32)	Overall (n=160)
HOV lane open to all traffic next 17 miles	94	97	75	100	88	91
"Hoover" lane is open	3	0	3	0	6	2
Diamond symbol with HOV Lane	3	0	3	0	3	2
Commuter lane with time	0	0	10	0	0	2
Don't know what HOV means	0	0	3	0	3	1
Other miscellaneous responses*	0	3	6	0	0	2

*No other single category contained more than 2 percent of the responses.

The issue of familiarity with the road usage (i.e., the existence of an HOV lane) leading to an easier time with interpretation of the sign was supported when researchers reviewed the average viewing times for the sign. Table 16 shows that the average viewing times for Dallas, Houston, and Brownsville were lower than for El Paso and San Antonio.

After gaining this initial impression of the graphic, researchers wanted to identify if the participants believed that they could use the HOV lane independent of whether or not they had a minimum number of passengers. Table 17 shows the percentages of participants who understood the sign versus those who had other interpretations of the situation.

Table 16. Sign 8 Average Viewing Times.

Location	Average Viewing Time (seconds)
Brownsville	23.3
Dallas	22.1
El Paso	36.2
Houston	20.69
San Antonio	30.3

Table 17. Interpretation Percentages for HOV Lane Situation.

Interpretation	Percent (%)				
	Brownsville (n=32)	Dallas (n=32)	El Paso (n=32)	Houston (n=32)	San Antonio (n=32)
Understood All Traffic Could Use HOV	63	53	60	81	72
Need 2 or More People in the Vehicle to Use Lane	3	41	31	10	12
Did Not Understand HOV	6	3	9	6	16
Trucks Can Not Use Lane	25	0	0	0	0
Other	3	3	0	3	0

These data show that there was a low level of understanding for all of the study locations except Houston. This result was not unexpected for this portion of the study as the infrastructure portrayed in the graphic was most familiar to Houston drivers and was therefore more easily interpreted, giving them a greater chance to identify other details within the sign such as the fact that the HOV lane was open to all traffic. The Brownsville results reveal that the major issue for these participants was overcoming the influence of normal operational expectations. These expectations were demonstrated in the fact that 25 percent of these participants did not believe that the message would apply to large trucks. In all of the other locations, researchers identified that the major interpretation issue was that the participants still believed there needed to be multiple passengers in the vehicle to allow them to use the lane. Although this is an accurate interpretation for typical HOV lane operations, it showed that they did not gain the information from the graphic that the lane was available for all traffic due to the emergency situation.

Given this interpretation of the sign, researchers believe that familiarity with the infrastructure portrayed in this type of graphical display can have a major influence on how quickly and accurately the graphic is interpreted. This result implies that most of the information being delivered in this format be directed at familiar driver or commuter population and would not as greatly influence the actions of unfamiliar or pass-through drivers.

When asked if they would use the HOV lane, the main concern of the participants who believed they would consider using the lane was identifying the path that would have the quickest travel time or conditions. For those who would not use the lane, it was mostly stated as a preference for the main lanes believing that this is a path that allows more options or would

not be as restricted in traffic flow. The concern of the people who would use the HOV lane was further echoed in the additional information that the participants felt was needed on the sign. Overall, 30 percent of the participants felt there was a need to show travel conditions or times for all of the lanes so that they could make a route choice.

The final questions asked for this topic area were related to a comparison of different graphics. Participants were asked to identify which graphic they preferred to provide the information that the HOV lane was open but that there was not an available exit for 17 miles on this facility (Figure 28). Table 18 shows the preferences of the participants broken down by location.

Table 18. Participant Preference for HOV Lane Situation.

Responses	Percent (%)					
	Brownsville (n=32)	Dallas (n=32)	El Paso (n=32)	Houston (n=32)	San Antonio (n=32)	Overall (n=160)
Sign 8	19	44	44	28	50	36
Sign 8a	13	3	3	19	9	10
Sign 8b	68	53	53	53	41	54

As shown in the table, there was a distinct split in preference between Sign 8 and Sign 8b. The elements of these signs that participants indicated influenced their decision were the addition of the HOV symbol in the text box for sign 8b. Conversely, the participants who preferred Sign 8 indicated a preference for the text “next exit” versus “no exit” as used in the Sign 8b display. Given these decisions, researchers believe that the symbol did assist participants in understanding the sign and should be used to ease interpretation, but that the use of the wording “Next Exit 17 Miles” should be used versus “No Exit 17 Miles.”

ADJACENT TOLL LANES

This topic area evaluated two sign alternatives for adjacent toll lane facilities (i.e., where there are tolled or managed lanes adjacent to the primary freeway) as shown in Figure 29 and Figure 30. Through this study, researchers evaluated the ability of participants to identify the separated set of lanes as a portion of the facility traveling in their direction and for them to

identify it as a restricted toll facility (i.e., for toll tag users only). Also, researchers again introduced a situation where toll collection had been suspended due to the accident and wanted to identify the participants' driving decisions when there is no toll being collected.

The first element to analyze was if the participants recognized the left lanes as a toll facility. In this case, 95 percent of the participants did identify that it was tolled. However, only 48 percent of the participants were able to identify that the lanes could only be used by people who had a TxTag (toll tag). One positive note is that only two percent of the people believed that the lanes were for the opposite direction of travel. This shows that although the participants may not have fully understood the sign, the majority (98 percent) did recognize that all of the lanes shown were moving in their direction. Other misinterpretations of the TxTag lanes were that they were for anyone who pays (16 percent), all drivers (13 percent), or for people with Texas license plates (13 percent). From this information, researchers conclude that the general public does not yet have a good understanding of toll-tag-only facilities and more specifically of the TxTag system. Further public education on these points would help drivers to understand the purpose of the adjacent lanes in this graphic.

For the sign that indicated a suspension of the toll due to the accident on the main lanes, researchers were concerned that drivers could understand that there was currently no charge and to identify if they believed that would imply that the lane was open for anyone to use. When asked if they would have to pay a toll to use the left set of lanes, 84 percent of the participants accurately identified that they would not have to pay a toll. This result implies that the phrase "no toll" was well understood by the participants. Also, researchers saw an increase from 13 to 49 percent in the number of participants who thought that the lanes were open for anyone to use. This change is a positive step in driver understanding; however, there were still a significant percentage of people (22 percent) who believed that the vehicle would need to have a toll tag and 14 percent who believed that a vehicle must have Texas license plates. Again, researchers attribute the belief that a vehicle needed to have Texas license plates to the fact that the TxTag symbol was not well understood. However, with the misunderstanding of still needing a toll tag to use the lanes, researchers would recommend removing the TxTag symbol from the lane when suspending the tolls if the agency intends for all drivers to have access to the lanes for this condition.

One problem identified during the focus group was the recognition of which set of lanes the accident was located on. To try and remedy this concern, researchers moved that accident

information text box to be adjacent to the applicable lanes with an arrow pointing to the accident area. Also, indicators were added in the lanes as to which lanes were closed (X) or open (arrow). Based on this information, the majority of the participants for each sign option (96 and 97 percent) correctly identified that the accident had occurred on the main lanes. Additionally, the majority of the participants were able to correctly identify the street location of the accident for each sign (80 and 89 percent, respectively).

Researchers also asked people to identify the route they would take for the given situation. Table 19 shows the route selection by participants for each sign.

Table 19. Route Selection When Adjacent Toll Lanes Are Present.

Route	Percent (%)	
	Sign 10 (n=160)	Sign 10a (n=160)
Continue on Main Lanes	38	20
Take Toll Lanes	48	69
Take Cross Highway	5	4
Local Streets	3	3
Service Road	5	2
Other	1	2

With regard to the two scenarios given (toll versus no toll on the adjacent lanes) there was a statistically significant increase in the participants who would take the toll lanes if the toll was suspended during the incident. For the scenario with no toll (Sign 10a) the participants commented that they made this route selection based primarily on the fact that there was not a toll collection in effect and that it would allow them to avoid the accident area. One further point was that the majority of the participants (85 percent) believed that in a no toll situation all vehicles could use the toll lanes.

Researchers also wanted to determine if the absence of color-coding to indicate traffic congestion garnered a change in diversion decisions from the study participants. To accomplish this analysis, the team compared the results of the current section as illustrated in Table 19 with those from the first section of the analysis illustrated in Table 7. This comparison was possible as the comprehension protocol used throughout the study was equivalent and therefore comparisons could stretch across different sections to look at elements of interest within the graphical displays.

Table 7 shows that the greatest percentage of participants who indicated they would stay on the main highway was 26 percent. This was an increase within that section due to congestion levels shown on the cross highway. However, the results for the current section revealed that Sign 10 had an even more significant percent of participants (38 percent) who stayed on the main highway when no traffic conditions were given. Researchers ran a test of proportions on this information and found that the increase was statistically significant for the sample. Given this result, researchers concluded that a significant portion of the participants did use the congestion coloring as a basis for their route decisions. Therefore, given that decision making ability and route selection in particular were driving factors for the graphical signs, the researchers recommend the use of color-coding to indicate congestion in graphical displays.

Researchers also wanted to identify the ability of participant to recognize or interpret the TxTag symbol that was used on the toll lanes. Table 20 shows the responses of participants as to the meaning of this symbol following their viewing Sign 10.

Table 20. TxTag Symbol Interpretation.

Response	Percent (%)
Toll Tag	58
Texas License Plate	21
Don't Know	11
Toll	5
Texas Highway	3
Other	2

The results presented in the table show that there is not a good understanding by the public as to what this symbol means. A good portion of the participants misinterpreted it to mean that it was only for people who had Texas license plates on their vehicles. This misinterpretation could be a concern in that they would not realize that they were violating the toll collection by using the system without a toll tag or that out of state drivers would not realize that it is feasible for them to buy into the system. This result again points to a need for greater public education regarding the TxTag toll collection network.

To examine different terms to indicate that a toll was suspended, three signs were shown as a comparison and preference evaluation to all of the participants. Figure 31 depicts these signs. Table 21 illustrates the selection of participants as to which sign they preferred.

Table 21. Preference for Terminology in a No Toll Situation.

Sign Option	Percent (%)
Sign 10a – No Toll	24
Sign 10c – Free	35
Sign 10d – Free, No TxTag Symbol	41

Overall, Sign 10d was preferred by the highest number of individuals, with 41 percent. However, the answers were decidedly split with 35 percent selecting Sign 10c and 24 percent Sign 10a. When questioned as to why they preferred a particular sign, the participants who selected Sign 10d indicated that this sign:

- better showed that the road was open to everyone,
- was simpler or easier to understand, or
- did not contain the confusing TxTag symbol.

For Sign 10c, the primary response provided by participants for preference was that the term "free" was more to their liking. For Sign 10a, the people who selected this sign indicated that "no toll" was easier to understand or more professional than "free." Given that there was no clear indication of preference, researchers recommend the removal of the TxTag symbol from the graphic when tolls are suspended; however, given that both "no toll" and "free" were understood and that there was a split preference, either was acceptable for use on the graphic.

TRUCK ROUTE GRIP

In the final topic area of the human factors study researchers focused specifically on the large-truck driver population. Due to this focus, the participants who were recruited in Brownsville were exclusively large-truck drivers who traveled extensively across the state of Texas. These participants will be the focus of the analysis in this section. However, all of the participants were asked for their interpretations and preferences within this area to ensure that the information provided would not confuse or mislead the average driver.

Truck Driver Perspective

First researchers wanted to explore whether the large-truck drivers could identify that a bypass route around the San Antonio and Austin metropolitan areas was being recommended for their use, but was not a required route. In response to an open question regarding the

information on the sign, 66 percent of these participants stated that the graphic was showing a truck route to Waco. In a more pointed question, researchers asked the truck drivers if they were required to take a specific route based on the graphic. In this case, 56 percent believed that they were required to take the truck route shown. However, of those drivers who did not believe they were required to take the truck route, an additional 44 percent did understand that it was a specified truck route but thought this was an optional route or that it was only required for hazardous materials cargo. This result implies that although the drivers could identify that a route was illustrated for large-truck traffic, there was confusion as to what the requirements were with regard to the use of this route. If this type of signing is used, further information will need to be provided with this sign to ensure that the truck drivers are aware that this is an optional route and not a requirement.

Further insight into the participants' decision making was gained through asking them to identify what route they would take to get to Dallas. Table 22 shows the percentage of participants who stated they would take the different identified routes.

Table 22. Percent of Truck Drivers Selecting Different Routes.

Route	Percent (%)
Continue North on I-35	31
Follow Given Truck Route	66
Other	3

The table illustrates that the majority of the truck drivers elected to follow the specified truck route. When questioned as to why they made this route decision, the majority of the participants who selected the truck route identified that they made this choice based on the fact that it was a designated truck route (57 percent). The second most common response was that this route would avoid the congestion shown in the graphic (29 percent). For the participants who opted to stay on the main freeway, the most common responses as to why they made this decision were:

- it is a simple route (45 percent),
- the driver did not want to pay a toll (27 percent), or
- traffic is moving for most of the route (27 percent).

Each of these responses identifies different characteristics of the driving decision and graphic used in the truck-drivers decision making process. First, they desired to follow a direct or familiar route to reach their destination, this is critical in that providing signing pointing them to a new or unfamiliar route may not have the desired effect simply based on unfamiliarity with that roadway. Secondly, the presence of a toll collection facility as part of the truck route was a deterrent to many of the participants. Again, this could lead to reduced success of a suggested truck route due to drivers' hesitation in incurring extra costs. Finally, the drivers did not feel that a traffic problem located a significant distance away would influence them to select a different travel route. This decision making insight indicates that providing information outside of an immediate metropolitan area as a means of trying to reroute traffic away from the area may not be effective unless a greater sense of urgency is present for a given situation (e.g., road closed).

Finally, researchers asked the participants to specifically identify what information within the graphic influenced their driving decision. Table 23 shows the responses of the participants. Note that the percentages in the table will add up to greater than 100 percent as the participants were able to provide more than one piece of information that influenced their decision.

Table 23. Information that Influenced Route Decisions.

Information Element	Selected Route	
	I-35 (%)	Truck Route (%)
Congestion Coloring	9	38
Avoid Trucks Shown on Graphic	6	
Familiar Route	6	
Didn't Have Tollway	6	
Truck Route Shown	13	34
Other	3	

Knowing the above information, researchers also asked the participants to review different options for ways to provide information regarding an optional truck route. The first feature that researchers evaluated was alternative wording to identify an optional truck route. There were three phrases that were evaluated: truck route, best route, and bypass. Table 24 shows the percent of participants selecting each option.

Table 24. Truck Driver Selection of Route Identification Wording Alternatives.

Route	Percent (%)
Sign 12a: Truck Route	16
Sign 12b: Best Route	56
Sign 12c: Bypass	28

As illustrated in the table, the most preferred option was the one that stated it was the "best route." Drivers liked the wording of this option as it was familiar and easy to understand that as the fastest or easiest route to use. For the term "bypass," there were several responses that this term was unfamiliar making it a less popular option. Overall, the use of these terms depends highly on what is expected from the alternate route. If "best route" is used as terminology, officials will need to ensure that this is a true statement and that the travel time or inconvenience is reduced based on the use of this route. Also, the term "truck route" had much more of a requirement implication. The term "optional" may be added to this phrase to ensure full understanding by drivers.

The second comparison that was done for this area was focused on the inclusion of truck icons on all segments of the route versus only at critical turn movements (Figure 34). In this scenario, 75 percent of the participants preferred the use of icons on all segments of the alternate route. They believed that this was a better designation of the route they should follow and was easier to understand. Researchers would recommend applying this methodology to any scenario where a specific path is identified.

Finally, researchers wanted to identify what information was most important within the signs. In this case, the different options looked at the inclusion of congestion information via color, time savings, and the inclusion of both congestion coloring and time savings. Table 25 shows the preference of the truck driver participants.

Table 25. Truck Driver Preference of Time and Congestion Indications.

Route	Percent (%)	Avg. Ranking
Sign 12d: Congestion Coloring	3	2.4
Sign 12e: Travel Time Savings	22	2.3
Sign 12f: Both Coloring and Time Savings	75	1.4

Again, a 75 percent majority preferred the option that showed both the congestion coloring and the travel time savings gained by using the alternate route. They believed that the

inclusion of both of these elements provided the most information for the given situation. Also, when participants were asked to rank these signs in order from best to worst based on the information provided, Sign 12f was again the favorite. While the other two signs were very close to each other in ranking, they were not as well received as the combined information.

General Driver Perspective

Within the general driver perspective, the researchers' primary concern was that in providing information that was specifically aimed at the truck driving community the signs did not confuse other drivers on the roadway. In this case, researchers primarily looked at the route decisions of the drivers to ensure that they did not feel they had to follow the designated truck route as well as the information that they were using to influence their route decisions. Table 26 shows the percentage of general drivers who selected the different routes. This is a combined total for all of the other four locations included in the study.

Table 26. Percent of General Drivers Selecting Different Routes.

Route	Percent (%)
Continue North on I-35	47
Follow Given Truck Route	46
Other	7

As the table shows, the drivers were evenly split between those that would stay on the traditional route (I-35) to Dallas and those that would follow the truck route that was outlined on the sign. Researchers further investigated the reasons that participants selected the different routes to ensure that they were taking the truck route voluntarily and not believing that they were required to change routes. This information showed that the majority of these people (95 percent) elected to use the truck route because they could avoid the congestion that was illustrated on I-35 and that they would save time. This would indicate that these drivers were not confused, but were making good driving decisions based on the congestion information provided on the sign. Also, for the drivers electing to stay on I-35 for this trip, they stated that they would use this route because it was simpler (80 percent) or that it would avoid truck traffic on the other route (19 percent). Again, this shows that the drivers were making route selection decisions based on the signs and were not confused by the information provided.

It is interesting to note that the preference questions detailed above for the truck drivers were also asked of the general drivers group. For these three selections, all of the preferences

selected by the general driver participants matched those indicated by the truck drivers. Therefore, the selections indicated above would be appropriate for use without confusing the general driving population.

SUMMARY

Researchers developed the Level 1 Laboratory Study discussed in this chapter to identify ability of drivers to comprehend and use information presented in a graphical electronic format on roadway signs. Through this study, researchers have identified elements within these signs that enhance or detract from this information. The information below highlights some of the main findings within each section of the study.

Graphic Interchange Information

The first topic area of the study looked at a simple graphical representation of an interchange area where an incident had occurred downstream of the interchange. Figure 36 shows an example of this type of graphic.

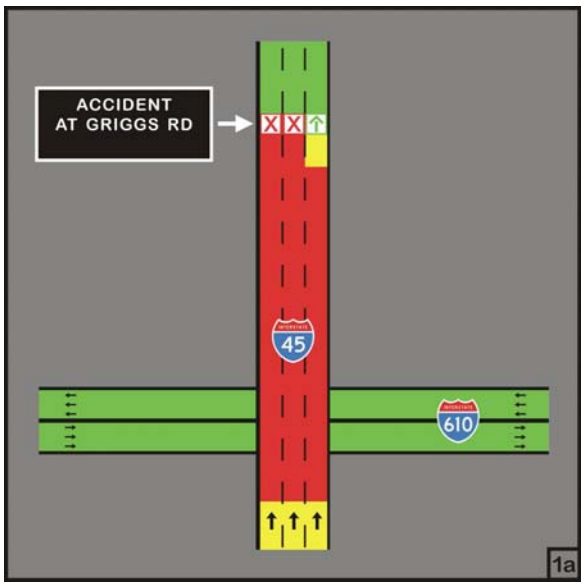


Figure 36. Graphical Interchange Example.

The key findings from this section include the following.

- The majority of participants were able to correctly interpret the use of color-coding for congestion information.
- The accident symbol was understood as well as text with regard to what type of event had occurred.
- Include an arrow in the open lane to assist drivers in identifying this lane as an available path.
- Interpretations of accident severity and congestion levels have a significant impact on route decisions.
- A three-dimensional perspective of the interchange (Sign 4) did not improve driver understanding of the information provided.
- The inclusion of graphic ramps on the sign are not required for participants to understand that they can exit to the cross highway.
- Showing incident location through graphic cross streets reduced the level of comprehension as compared to simple text location information and is therefore not recommended for use.
- The work zone symbol was preferred over the text "roadwork" on the signs.
- Participants were able to identify toll facilities based simply on the inclusion of toll route shields on the cross highway.

GRIP Information

The GRIPs included in this study represented both a full view of a metropolitan area and a half view of the area that was impacted by an incident. Based on the participants' viewing of these images, the following key findings were obtained.

- Participants could identify the accident location for both views evaluated.
- The half versus full view of the area did not have a significant impact on the drivers' decision to take an alternate route.
- The viewing time for the half view was not significantly less than that for the full view, implying that the workload on drivers was not significantly reduced by this change.

In addition to the above findings, no clear preference for one view over the other was obtained from the participants. Therefore, either view is appropriate to use depending on a given location for an incident on a sign and the impact that dividing the view may have on drivers.

HOV Lane Identification

The next portion of the study looked at the participants' ability to identify an HOV lane graphically as well as a change in operations for this lane based on an emergency situation. The following were the key findings with regard to the HOV lane representation used in this study.

- The ability of participants to identify the function of the HOV lane was highly dependent on the local knowledge of HOV lanes.
- When drivers were familiar with the HOV lane infrastructure depicted, the majority of the participants were able to identify that the lane was open to all traffic. Otherwise, the information was not well understood by the participants.
- Given the familiarity influence, information given about a unique infrastructure within a region needs to have a primary focus of impacting local or familiar drivers only.

Adjacent Toll Lanes

Again, the graphic presented unfamiliar roadway geometry; therefore, researchers' concerns were primarily on the participants' ability to identify the function of the different elements. The following were the key findings.

- Ninety-eight percent of the participants were able to identify that the adjacent lanes were moving in the same direction as the main lanes.
- The majority of participants also identified that it was a toll facility that was adjacent to the highway. However, only 48 percent realized that drivers would need to have a toll tag to use this facility.
- In a scenario of suspended toll operations, the majority of participants did recognize that they would not have to pay a toll during a specific period.
- The absence of congestion color coding had a negative impact on the percent of participants who would choose to use an alternate route.

- The TxTag symbol used in this study was not well understood by drivers and could use the influence of public education to further enhance driver comprehension and compliance with toll-tag-only facilities.

Truck Route GRIP

The focus of this section was to obtain large-truck drivers' interpretations of an optional truck route that would bypass major metropolitan areas. The key findings related to this section are as follows.

- Approximately half of the participants did not understand that this was an optional route for truck drivers.
- For the participants who believed they had an option with regard to their route, the driving decisions stated showed that these drivers
    - desired to follow a familiar route,
    - based route decisions on avoiding a toll facility, and
    - were not overly influenced by traffic problems shown to be a significant distance away.
- Participants preferred a sign option that provided both congestion color coding and time savings shown for the alternate route to illustrate the benefit of that route.
- The general driver participants were not confused by the inclusion of truck only information on the graphic sign.

CHAPTER 5: LEVEL 2 HUMAN FACTORS LABORATORY STUDY

Based on previous TTI research experience in the development of static symbol signs and DMS messages, the TTI research team acknowledged that the Level 1 laboratory study would not yield design features for each situation and/or site type that could be considered as the "best" design. As such, the designs were modified and improved and incorporated into a Level 2 laboratory study. In the Level 2 study of the DMS symbol and graphic designs researchers evaluated the new modified designs as well as comparing the reaction of participants to these graphics as opposed to a standard text message.

STUDY DESIGN

The goal of this study was to determine driver comprehension and informational demands of the modified symbol and graphics designs as well as to introduce an evaluation that compared understanding and decision making for a graphic design as compared to standard text messages. As in the Level 1 laboratory study, participants viewed the candidate signs displayed on a computer monitor. The capabilities of the computer allowed incorporation of symbols, graphics, and color into the designs. The study was conducted using two methodologies. The first methodology was a self-paced or unlimited viewing time study, and the second used a limited or fixed time method. The unlimited viewing time methodology allowed participants to view a message or graphic until they were confident that they understood the information. The message exposure time for each participant was recorded in this study to compare the times for alternative designs as a means of identifying what options or formats were more easily understood. The fixed time methodology did not allow participants to control how long they viewed the message. In this methodology, the message was displayed for a standard eight seconds and then it automatically was removed from the viewing screen. As in the Level 1 laboratory studies, the street names and locations were changed according to the study city location for all of the design options used. After each message was displayed several questions were asked to evaluate participant comprehension and decision making.

Study Issues

There were three different topic areas that were examined in this study. The topic areas consisted of:

1. graphic versus standard text messages,
2. indicating severity of an accident, and
3. understanding of the work zone scenario.

The first area used both the self-paced and fixed time methodology of evaluation while the other two sections used only the self-paced method. A test message, as shown in Figure 37, was displayed prior to the beginning of each methodology used in this study to help the participants get familiar with the protocol (self-paced or fixed timing).

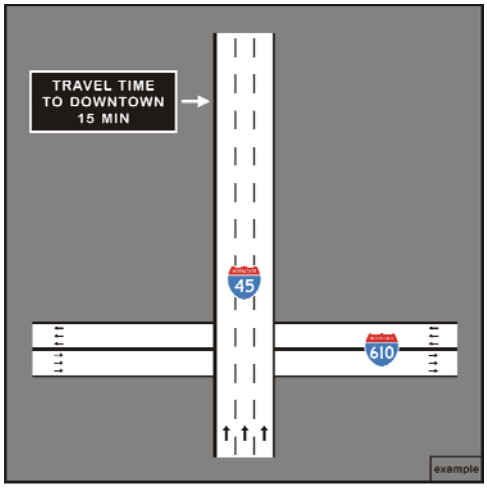


Figure 37. Example Graphic.

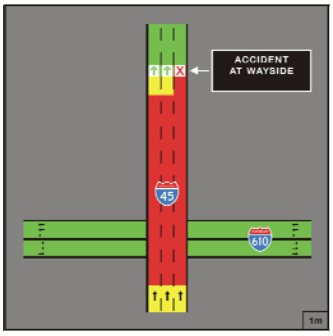
Topic Area 1. Graphic versus Standard Text Messages

The first part of this section was conducted in the self-paced methodology. There were four options of graphic designs and text messages with equivalent information for the driver. These alternatives were used to determine how the different information display formats would affect driver decision making such as taking an alternate route and lane selection. Figure 38 shows the four graphic designs used in this section, with the text messages illustrated in Figure 39. Each participant saw one option that had a two-lane closure as either the graphic or text format and one that had a single lane closure in the opposite format. Additionally, for each participant one of the options they saw included specific delay information while the other option

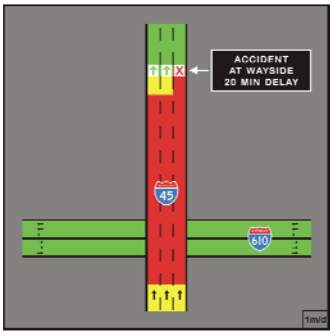
did not. To determine if they would take an alternate route and lane selection, the participants were asked:

- how likely they were to leave the highway and take a different path to their destination,
- what lanes they could drive through, and
- how much extra time they expected their trip to take based on the information they had just seen.

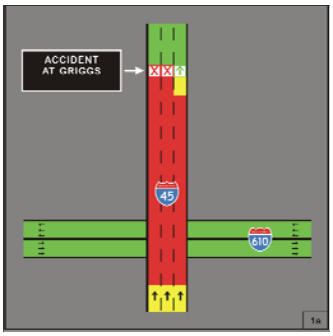
The second part of this section was conducted in the fixed-time methodology. Researchers wanted to determine if having a limited amount of time to view the graphic or the text message would impact the information obtained by the drivers. The participants were shown one option, either a text or graphic which contained opposite lane closure and delay information as they had seen for that format earlier in the study. The alternative selected was displayed for eight seconds and then automatically was removed from the viewing screen. Questions were asked to identify what information they were able to obtain on their decision making choices. The questions queried participants regarding lane selection, likelihood of diversion off the highway, and how much extra time they expected the trip to take.



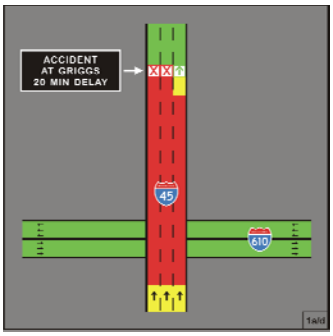
(a) One Lane Blocked – No Delay



(b) One Lane Blocked – Delay



(c) Two Lanes Blocked – No Delay



(d) Two Lanes Blocked – Delay

Figure 38. Section 1 Graphic Signs.

Phase 1 **Phase 2**

(a) One Lane Blocked – No Delay

(b) One Lane Blocked – Delay

Phase 1 **Phase 2**

(c) Two Lanes Blocked – No Delay

(d) Two Lanes Blocked – Delay

Figure 39. Section 1 Text Messages.

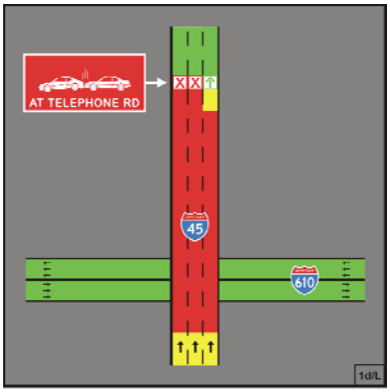
Topic Area 2. Indicating Accident Severity

The purpose of this evaluation was to determine if it was possible to convey the severity of an accident to a driver through the use of different accident symbols or affected lane areas. Two different symbols were evaluated in this section; one symbol was the C-4 symbol that was selected the "best" symbol to use to indicate an accident in the Level 1 laboratory study. The second symbol was a variation of this same symbol but showed more extensive damage to the vehicles in the symbol. The Level 1 laboratory study had suggested this increase in damage as a means of conveying a major accident to drivers. Additionally, the congestion levels shown in the graphics were altered to determine if this information was a deciding factor for participants when making route decisions. Figure 40a and Figure 40b show the C-4 symbol with a long and a

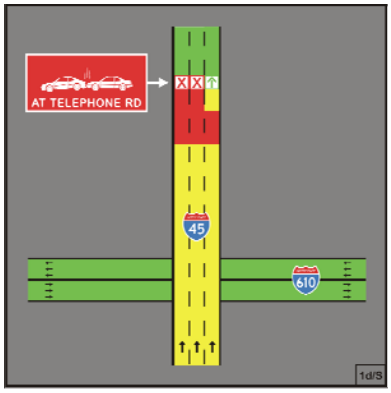
short congested area, respectively, whereas Figure 40c and Figure 40d illustrate the new symbol with both the long and short congestion area.

The participants were shown these messages in the self-paced methodology, indicating they could view the signs as long as they felt necessary. The participants were asked

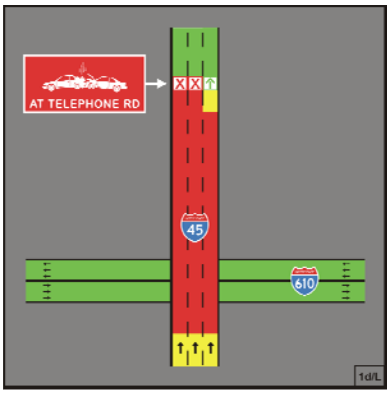
- how likely were they to leave the highway and take a different path to their destination,
- what event was occurring on the road,
- whether it was a major or minor problem, and
- how much extra time they expected their trip to take based on the graphic information.



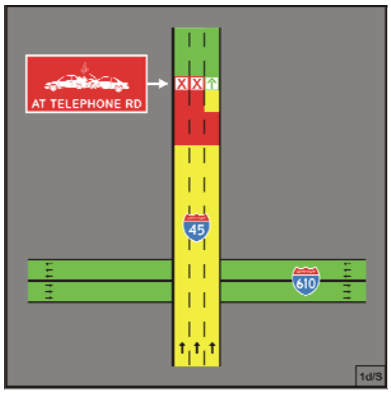
(a) C-4 Symbol Long Congested Area



(b) C-4 Symbol Short Congested Area



(c) New Symbol Long Congested Area

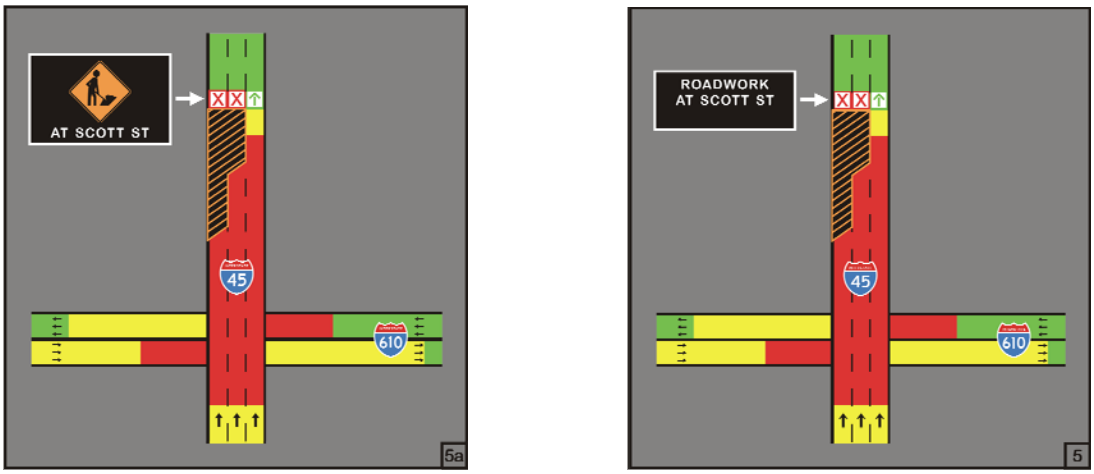


(d) New Symbol Short Congested Area

Figure 40. Accident Severity Graphic Alternatives.

Topic Area 3. Understanding of Work Zone Scenario

In the Level 1 laboratory study the work zone lane closure and symbol graphics were evaluated only for driver preference and not for initial comprehension. As such, researchers decided to evaluate these alternatives for drivers' comprehension of both the work zone symbol and the lane closure display. This evaluation was accomplished by querying participants as to their lane selection for the given scenario, what event was ahead, and how likely they were to divert from the highway. Figure 41 illustrates the two sign options used in this section. These graphics were evaluated using the self-paced timing methodology.



(a) Symbol Sign **(b) Text Sign**

Figure 41. Work Zone Graphic Alternatives.

Data Collection

The laboratory instrument developed for this study consisted of three topic areas. To avoid the occurrence of primacy bias, the order of the alternatives was interchanged in eight different surveys. The laboratory instrument was also developed in Spanish because in two of the cities (San Antonio and El Paso) half of the surveys were conducted in English and the other half in Spanish. Examples of the survey used to administer this study in both English and Spanish is in Appendix C. Researchers aimed to collect 240 surveys per survey location. There were two additional surveys conducted in San Antonio that resulted in a total of 962 surveys, 721 surveys in English and 241 surveys in Spanish.

Study Locations

The study was conducted in four of the five Texas cities that were used in the focus groups and in the Level 1 laboratory studies: Dallas, El Paso, Houston, and San Antonio. The Brownsville sample had originally been recruited for the Level 1 laboratory study to obtain a sample of large truck drivers; additionally researchers recruited a significant portion of these participants as Hispanic drivers. In lieu of Hispanic large truck drivers, researchers decided to conduct the survey in Spanish in San Antonio and El Paso where there are concerns over drivers' understanding of English text messages. These laboratory studies were conducted at the Texas Department of Public Safety Driver's License Renewal offices in each selected city.

Demographics

The criteria used to select participants for the Level 2 laboratory study were the same as in the Level 1 study: a current driver's license, over the age of 18, and traveled at least 8000 miles per year. The latter criterion was used to ensure that the participants were frequent drivers that were familiar with the roadway system and the use of DMSs. As in the Level 1 study, researchers strived to recruit a sample of drivers based on the demographics of the driving population of Texas with regard to gender, age, and educational level. The statistics utilized for age and gender were obtained from the United States Department of Transportation – Federal Highway Administration Statistics for 2003. The education level statistics were based on the Texas information from the United States Census Bureau for the year 2003. Gender and education statistics indicated an even split of male versus female drivers as well as those with a high school diploma or less versus some college to a college degree.

Table 27 shows the demographic sample obtained and needed based on cross-referencing the gender, age, and education level of the Texas population for those participants that spoke English as their primary language. The numbers in italics represent the sample population obtained. The actual sample had a few more females than men in both education levels in the middle age category. While there were an adequate number of gender and education levels obtained overall, there were slightly more female than male participants. There were also fewer participants in the 55+ category and slightly more in the younger category. Overall, researchers feel that they achieved an adequately diverse sample for this study.

Table 27. Level 2 Laboratory Study Demographic Sample: English.

Age	Education Level				Total (n=128)	
	High School Diploma or Less (50%)		Some College + (50%)			
	Male (25%)	Female (25%)	Male (25%)	Female (25%)	Numbers	Percentages
<25	(26) *28*	(25) *25*	(25) *27*	(25) *28*	(101) 108	(14) *16*
25-54	(108) *102*	(109) *110*	(108) *106*	(108) *117*	(433) 435	(60) *59*
55+	(46) *42*	(47) *43*	(47) *45*	(47) *48*	(187) 178	(26) *25*
Total	(180) *182*	(181) *178*	(180) *178*	(180) *193*	*(721)* 721	100

NOTE: Numbers in italics represent the sample population obtained.

Table 28 shows the study participants that spoke Spanish as their primary language. As in the English speaking demographics, there were again more women that participated in the survey than men. Again, researchers feel that the demographic sample achieved was adequately diverse; however, there were fewer participants in the 55+ category and slightly more in the other two age categories.

Table 28. Level 2 Laboratory Study Demographic Sample: Spanish.

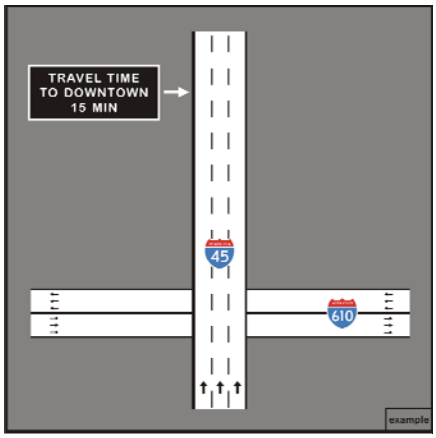
Age	Education Level				Total (n=128)	
	High School Diploma or Less (50%)		Some College + (50%)			
	Male (25%)	Female (25%)	Male (25%)	Female (25%)	Numbers	Percentages
<25	(8.5) *10*	(8.5) 8	(8.5) *8*	(8.5) *9*	(34) *35*	(14) *15*
25-54	(36) *33*	(36) *41*	(36) *35*	(36) *39*	(144) *148*	(60) *61*
55+	(16) *17*	(16) *17*	(16) *14*	(15) *10*	(63) *58*	(26) *24*
Total	(60.5) *60*	(60.5) *66*	(60.5) *57*	(59.5) *58*	(241) *241*	100

NOTE: Numbers in italics represent the sample population obtained.

Study Protocol

Upon recruitment, participants were provided with an explanation of the study and demographic characteristics (age, gender, and education) were recorded. The study administrator explained that the survey was evaluating different types of information that would assist drivers in making driving decisions while traveling on local highways. Each participant

was shown examples (Figure 42) of the two types of display formats that would be used in the study. Researchers explained that the graphic type of information would be displayed on a large electronic sign along the highway, much like the large electronic word signs they see now. Researchers also explained that for the graphic display the entire picture is what they would see on the sign, not just the black box on the left.



(a) Graphic Sign

ACCIDENT AHEAD
EXPECT DELAY

(b) Text Sign

Figure 42. Examples of Graphic and Text Signs.

Next, participants were given a map to review of the local metropolitan area to orient them to the area of interest in the study. The participants were told their beginning location, their destination, and which cardinal direction they were traveling to reach the given destination.

Participants were told that they would view several signs one at a time that would display different types of information. In the self-paced timing method each participant was told that when they pressed the space bar on the keyboard the first dynamic message sign would appear on the laptop monitor screen and they would have complete control over how long they viewed each sign. They were instructed that the instant they thought they understood the sign they needed to press the space bar once to turn the display off. At that point the researcher would ask questions about the information displayed on the sign. In the fixed timing section of the survey, researchers explained that the format would change and the image would appear for a limited amount of time. It would stay on the screen for a few seconds and then automatically turn off. Following this process, the researcher would ask questions about the sign shown.

RESULTS

The data analysis for this study was conducted using both trend analysis and statistical testing to identify how the different alternatives used in the graphic and text message designs affected the participants' understanding of the information presented and their route decisions. The following discussion presents the information obtained based on the three topic areas identified in the study design.

Graphic versus Text Message Information

The research team's primary concern during this section was to evaluate how drivers would use different information contained in either graphic or text displays and to determine if one of these options was superior to the other in conveying the needed information. As described above, there were four different scenarios used in this evaluation. The different elements evaluated in these scenarios were:

- two lanes closed,
- two lanes closed with specific delay information,
- one lane closed, and
- one lane closed with specific delay information.

There were both text and graphic displays for each of these scenarios and the researchers were evaluating if there was a difference in drivers' reactions based on the lane closure or delay information and if one of these formats was more easily understood by drivers.

Unlimited Time Display

The first analysis to address the issue of comprehension for graphics versus text was to evaluate the participants' comprehension of what lanes they were able to drive in for each of these scenarios. This analysis was conducted with the data separated by the language that the survey was conducted in (English or Spanish) to determine if the Spanish-speaking participant was better able to identify this information from a graphic format. Table 29 shows the percentages of participants who correctly identified the lanes that were available to drive in when passing the problem area.

Table 29. Comprehension of Lanes Available to Drive in – Unlimited Time.

Scenario	Percent Correct (%)			
	Text		Graphic	
	English	Spanish	English	Spanish
2 Lanes Closed	64	61	88	83
2 Lanes Closed w/ Delay Information	68	73	87	80
1 Lane closed	15	12	53	28
1 Lane Closed w/ Delay Information	13	10	53	36

The data given in the table show that there was a great increase in comprehension of lanes available for use when this information was presented graphically for both the English and Spanish-speaking participants. Text messages were not able to convey to participants how many and which lanes were available past the upcoming incident. This difference suggests that although the participants were local drivers and thereby familiar with the area, they were not able to distinguish how many lanes were available at a particular section of roadway due to the frequent expansion and contractions of right-of-way inherent within urban freeway sections. This point is one where graphics have a distinct advantage in conveying roadway geometry (i.e., number of lanes) to a driver at the point of a temporary lane blockage.

With the consideration of lane closure comprehension in mind, researchers evaluated the participants' delay expectations for each of the displays evaluated in this section. Using a chi-squared test of independence, researchers determined that there was no statistical difference between the language groups and therefore the data were consolidated for this analysis. Furthering this evaluation with the consolidated data set, researchers discovered that there was also no statistically significant difference between the delay expectations of the participants based on whether or not delay time was presented on the graphic. The only factor found to have a significant impact was the number of lanes that were closed. Figure 43 and Figure 44 show the delay expectations for the one and two lane closed scenarios, respectively. From these data, researchers identified that when two lanes were closed on the facility the trend of the expected delay shifted slightly to the right (i.e., the percentages increased for the higher delay intervals) indicating that the participants had a slightly higher expected delay for this condition. This analysis supports the idea that delay time or other excess text should not be added to a graphic

display but that the pictorial design should be utilized to provide as much information as possible.

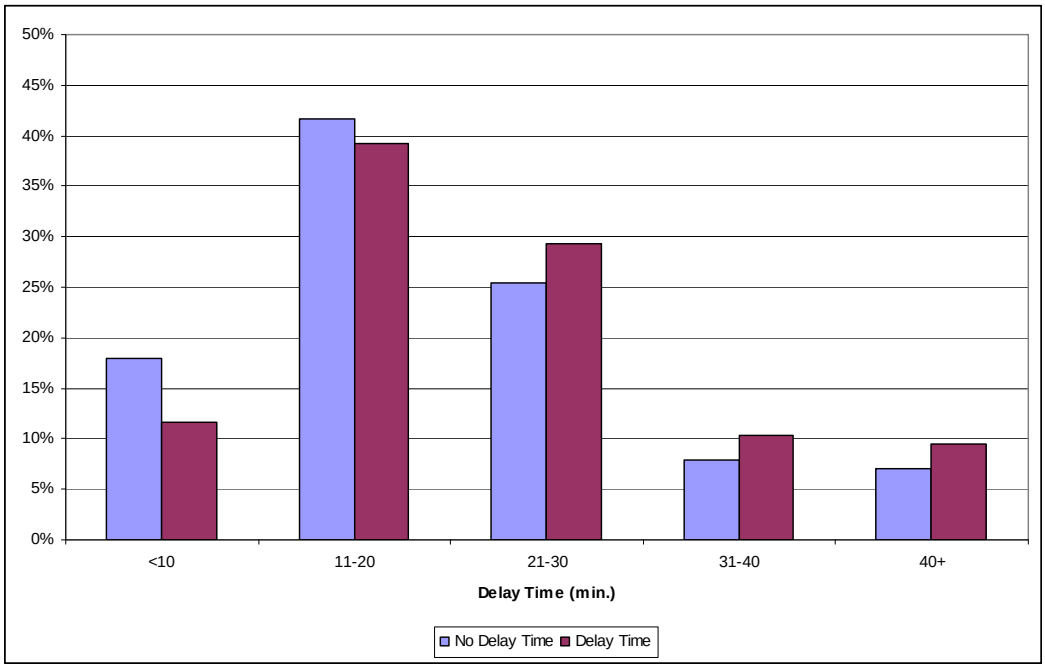


Figure 43. Expected Delay – One Lane Closed, Unlimited Display Time.

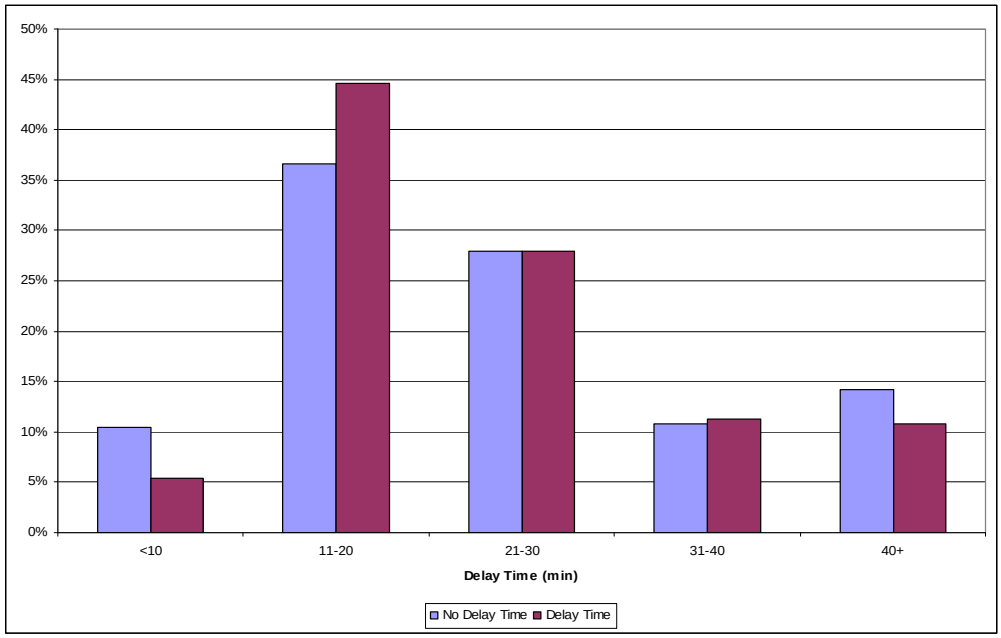


Figure 44. Expected Delay – Two Lanes Closed, Unlimited Display Time.

Researchers also evaluated whether participants were more or less likely to choose an alternate route if there was a greater number of lanes closed or if they were provided with a specific delay time. For this analysis, researchers identified for each scenario the probability on a scale of 1 to 7 (with 1 being will not change routes and 7 being definitely will change routes) how likely participants were to detour. However, based on a chi-square test of independence, researchers determined that there were no significant differences between the presence or absence of delay time within the information provided to the participant and their probability of taking an alternate route. Using this same test, researchers also found that there was no statistically significant difference in the responses provided by the English versus the Spanish-speaking participants. Given these conclusions, the data collected were consolidated into two groups looking simply at the impact of one versus two lanes closed on alternate route selection. Figure 45 and Figure 46, respectively, present this information.

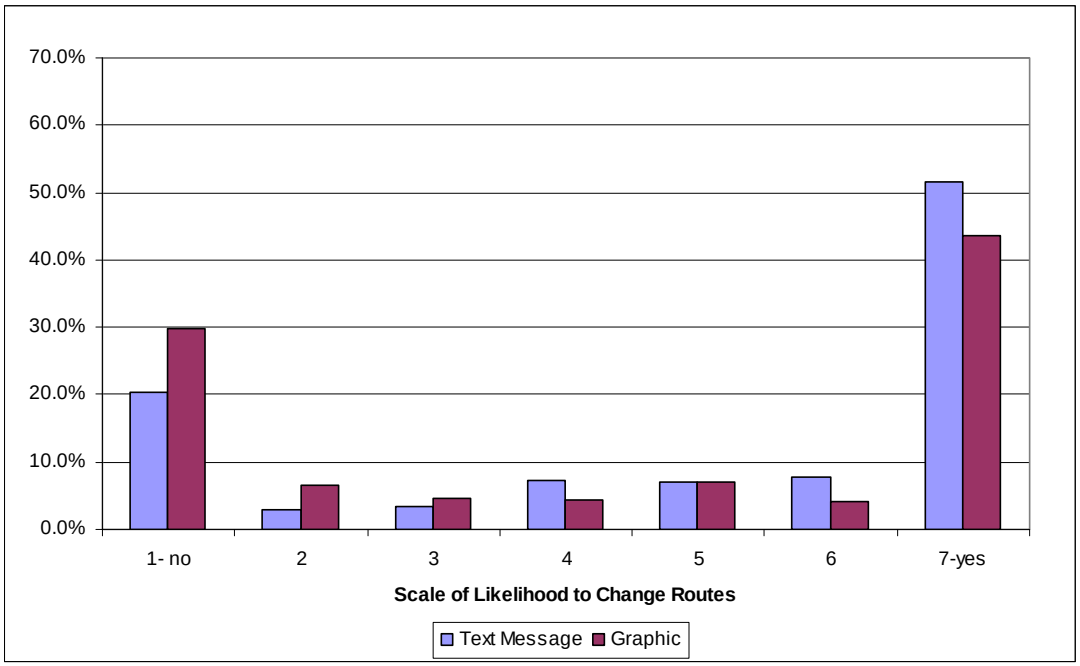


Figure 45. One Lane Closure, Unlimited Display Time – Likelihood to Change Routes.

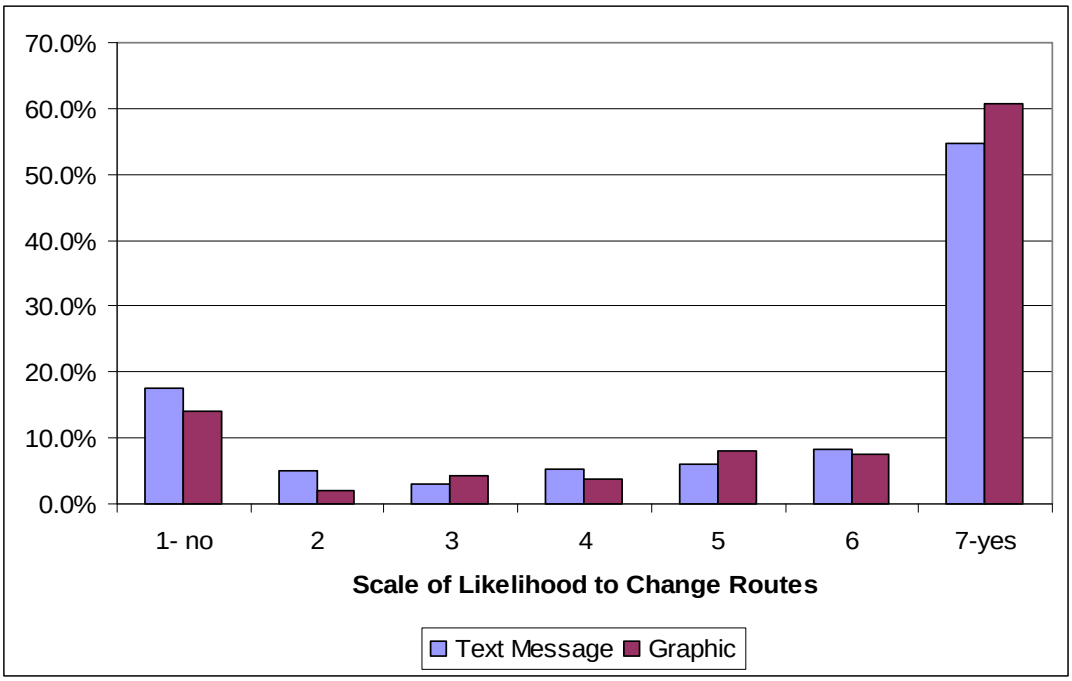


Figure 46. Two Lane Closure, Unlimited Display Time – Likelihood to Change Routes.

As the figures show, the likelihood of participants to choose an alternate route increases when there are two lanes closed as opposed to only one lane. This increase was particularly true for the graphic format of the information where, at the far end of the graphs, the participants who stated they would definitely change routes when one lane was closed were 44 percent as compared to 61 percent when two lanes were closed. Researchers believe this trend is less pronounced for the text messages (only 52 percent when one lane was closed versus 55 percent when two lanes were closed) as the participants had a more difficult time with these messages in identifying how many lanes were available near the accident site and therefore did not realize that there were two versus one lane available for them to drive in for the different scenarios.

Another data point that was evaluated to determine the participants' ease with interpreting the given information (either text or graphic) was to record the amount of time that a participant viewed a particular option. Table 30 shows the viewing times recorded for each of the alternatives evaluated in section 1 of the study. Additionally, it includes one of the graphics used in section 2 of the study to compare the time difference when using a symbol to illustrate an accident on the graphic.

Table 30. Section 1 Viewing Times.

Scenario	Viewing Time (seconds)			
	Text		Graphic	
	English	Spanish	English	Spanish
1 Lane closed	13.3	15.3	9.9	11.2
1 Lane Closed w/ Delay Information	7.5	8.6	10.8	10.9
2 Lanes Closed	13.5	15.9	9.7	10.7
2 Lanes Closed w/ Delay Information	8.9	10.6	11.1	13.4
2 Lanes Closed w/ Accident Symbol			9.0	8.9

Table 30 illustrates that in adding delay time information to the graphic display, there is a considerable increase in the time it took participants to interpret the graphic as compared to a text message that included delay. This increase was between 2 and 3 seconds, on average, depending on the alternative and language group. Researchers believe that the longer viewing time highlights the importance of allowing the graphic and symbolic information to stand alone in portraying information to drivers and that additional text should be avoided to allow drivers to interpret the information in a timely manner. This formatting recommendation is a particularly critical point given that the route change decisions made by the participants were not significantly impacted by the addition of delay information onto the graphic.

When researchers evaluated the language groups individually, the Spanish-speaking participants took an increased amount of time to interpret all of the displays as compared to the English-speaking participants. For three of the four graphics scenarios there was an improvement in this trend having less of a time increase (or differential) between the language groups than researchers observed with the text messages. However, there was still an increased interpretation time for the Spanish-speaking participants with the graphics. Researchers believe this trend could be due to the fact that there are still English-language elements within the messages (e.g., accident or delay). To determine if further inclusion of symbols into this display would again garner an improvement in the time differential, researchers included a graphic from topic area 2 in this analysis. This graphic included a symbol as opposed to text to represent the accident. In this case the Spanish-speaking participants showed a 7-second faster viewing time (i.e., 15.9 versus 8.9 seconds) compared to the text message and a 1.7 second improvement over

the previous graphic (i.e., 10.7 versus 8.9 seconds). This improvement was also true for the English-speaking participants but to a lesser degree (4.5 seconds faster for text and 0.7 second for the graphic with text element). This analysis supports the conclusion that not incorporating as many text elements into the graphic, but instead allowing it to stand alone, can improve the ability of drivers to identify the given information.

Fixed Time Display

The second analysis in this topic area evaluated the changes that occurred in comprehension and decision making when the designs were displayed for only a fixed amount of time (i.e., eight seconds). The first element of this analysis is to evaluate how time limitations impact the understanding of open lanes. Table 31 shows the percentages of participants who understood what lanes were available under the fixed time format.

Table 31. Comprehension of Lanes Available to Drive in – Fixed Time.

Scenario	Percent Correct (%)			
	Text		Graphic	
	English	Spanish	English	Spanish
2 Lanes Closed	73	77	84	80
2 Lanes Closed w/ Delay Information	86	90	90	83
1 Lane closed	7	13	56	37
1 Lane Closed w/ Delay Information	16	3	61	47

When the information in the above table was compared to Table 29, there was not a significant difference in the percentage of participants who identified the correct lanes between the two display formats. Again, the graphics displays showed an increased understanding of the available lanes as compared to the text messages for the majority of the scenarios. Additionally, the pattern was repeated that it was extremely difficult for the participants to identify the number of available downstream lanes when a one lane closure was presented as a text message.

In analyzing the impact upon the decision to change routes, researchers again used a chi-square test of independence to identify that there was no statistically significant difference between the data sets based on either language or display of delay time. Given that these elements did not produce a difference, lane closure was still the primary deciding factor used by

the participants to change routes. Figure 47 and Figure 48 show the graphs that illustrate this consolidated data set.

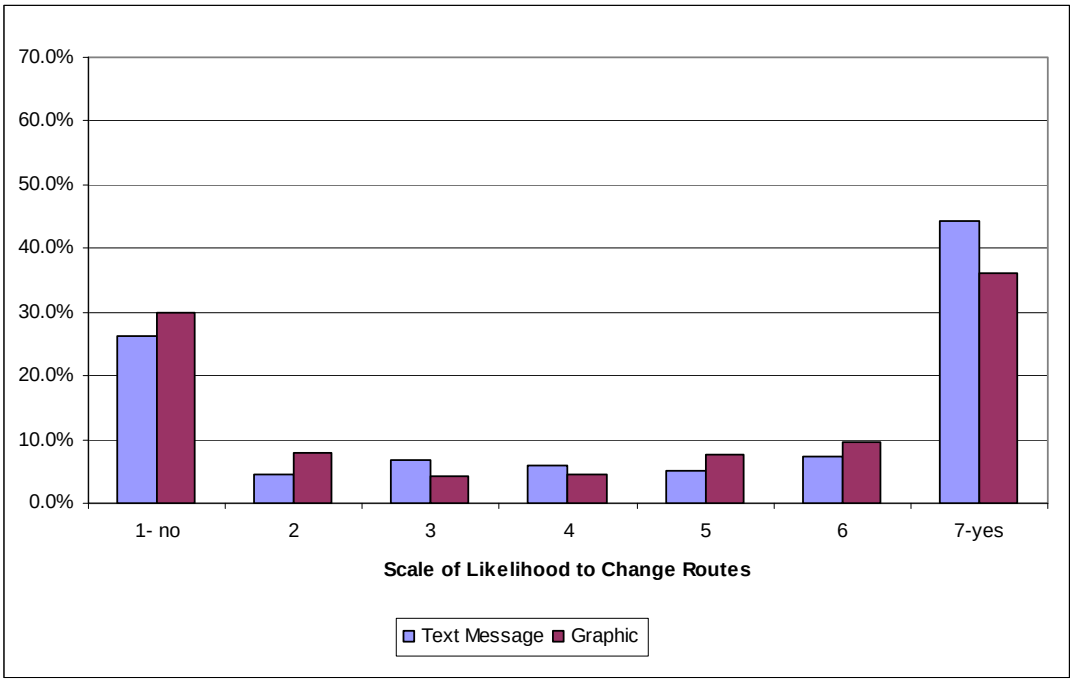


Figure 47. One Lane Closure, Fixed Display Time – Likelihood to Change Routes.

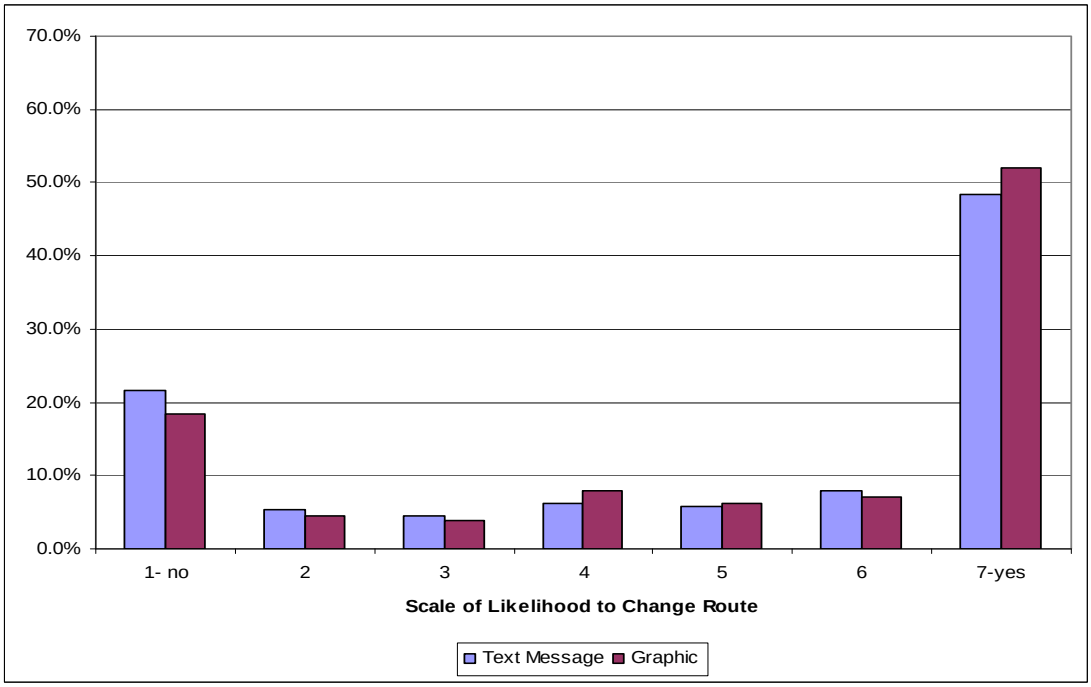
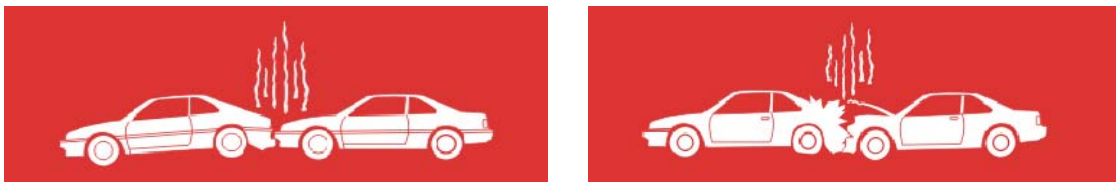


Figure 48. Two Lane Closure, Fixed Display Time – Likelihood to Change Routes.

As compared to the graphs that represented the unlimited display time data (Figure 45 and Figure 46), there was a shift in the trend of participants who would change routes away from a definite decision to change (i.e., to lower numbers on the scale). This shift is suitably illustrated when looking at the percent of people who would definitely change lanes in the two lanes closed scenario for the graphic display where the unlimited time scenario was 61 percent and the timed scenario was only 52 percent. Researchers attribute this trend to the fact that participants did not have as much time to view the designs or messages and were therefore less confident in their decisions to change routes. However, the finding that a greater number of people were likely to change routes when two lanes were closed as opposed to one was not impacted.

Indicating Accident Severity

The second topic area of this study looked specifically at the ability of a graphic display on a DMS to convey accident severity to a driver. For this evaluation there were two different symbols that were used (as shown in Figure 49) and different levels of congestion that were represented. These different elements were altered (as shown in Figure 40) to determine which had the greatest impact upon drivers' decisions.



Symbol A **Symbol B**

Figure 49. Accident Symbols.

Researchers' initial analysis looked at the participants' identification of the accident as either a major or minor event. Table 32 shows the responses of the participants for each of the different design alternatives.

Table 32. Comprehension of Accident Symbols.

Scenario	Percent (%)			
	English		Spanish	
	Major	Minor	Major	Minor
Symbol A, Short Congestion Area	51	49	49	51
Symbol A, Long Congestion Area	59	41	58	42
Symbol B, Short Congestion Area	59	41	65	35
Symbol B, Long Congestion Area	80	20	75	25

When looking at the information for Symbol A, there was a near even split between those who believed it was a major versus a minor accident when the delay section shown was short for both language groups. However, there was a slight shift to near 60 percent who believed it was a major accident when the congested area on the graphic was longer.

When the symbol with more damage (Symbol B) was used, there was a significant increase in the amount of people who believed it was a major accident for both delay times with between 75 and 79 percent believing it was a major accident when the delay section was long. This number was lower when it was a short delay time, only 59 and 65 percent for the English and Spanish groups, respectively; however, this was still an increase from the symbol with less damage. This information indicates that the participants used a combination of the information provided in the symbol and the roadway congestion level to make their decisions as to the severity of the accident.

Based on the chi-squared test of independence, there was no significant difference in the route decisions for the participants based on the length of the congestion that was displayed for either the English- or Spanish-speaking groups or for either of the symbol alterations. When comparing the language groups, there was also no statistically significant difference between these groups as associated with the congestion lengths. Figure 50 illustrates the similarity between the consolidated data for each symbol. Also incorporated into this figure is the same data for the graphics from Section 1 that had “accident” as text on the graphic. These data would imply that although drivers may draw conclusions as to the severity of the accident based on the graphic design, this information is not the deciding factor they use to determine if they should

take an alternate route. All three sets of data were not significantly different for the driver's decision on making route selection.

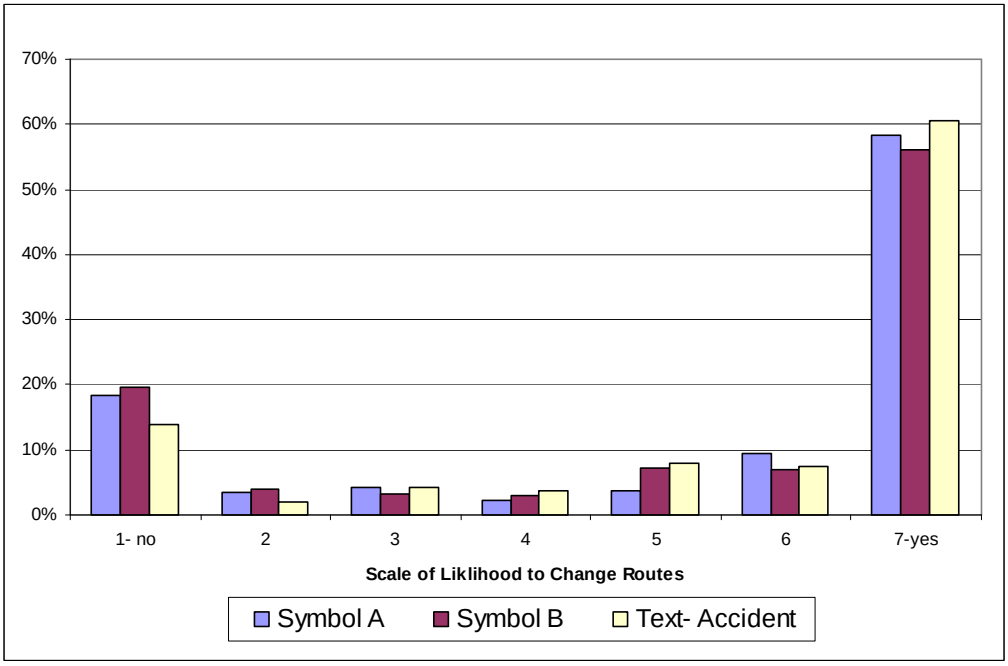


Figure 50. Accident Symbol Route Decisions.

The final query made of the participants for this section of the study was for them to identify the amount of delay they would expect to encounter based on the graphics. Again, the data were consolidated across the congestion levels displayed and the language groups based on a chi-square test. Although there was not a statistically significant difference between the two symbols either, looking at the trends portrayed in Figure 51 there is an increase in the expected delay identified for the symbol that showed greater vehicle damage (Symbol B) as more of the participants selected delay intervals at the higher end of the scale when this graphic was displayed. Also included in this graph were the data that represent the equivalent graphic from section 1 that used text for "accident." The data show that the trend identified previously, that the severe accident garnered a greater expected delay, also holds true for a comparison to the text message. However, since these changes are not significant it appears that the severity of the accident does not influence the expectations of the participants with regard to delay.

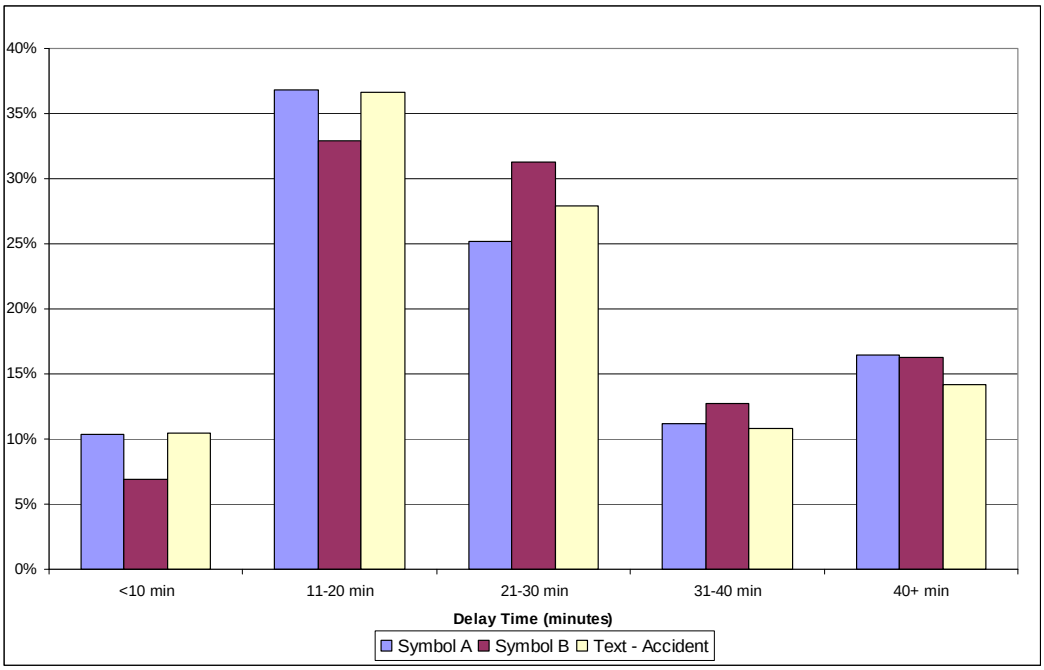


Figure 51. Accident Symbol Delay Expections.

Understanding of Work Zone Scenario

The final topic area of this study evaluated participant comprehension of a work zone scenario. Again, two alternatives were evaluated to determine how participants would interpret each design. The first design used a symbol (as shown in Figure 52) to identify the upcoming situation while the other employed the text "roadwork" for the same purpose. Table 33 illustrates the initial comprehension analysis to determine whether participants were able to identify the different designs as a work zone situation.

Figure 52. Work Zone Symbol.

Table 33. Work Zone Scenario Interpretation.

Scenario	Percent Response (%)					
	Construction		Accident		Other	
	English	Spanish	English	Spanish	English	Spanish
Symbol	80	90	11	3	9	7
Text	90	83	8	10	2	7

As shown, over 80 percent of the participants identified that the situation was a construction area for both the text and the symbol options. As expected, the English-speaking group of participants had a higher comprehension level for the text version of the design. However, the Spanish-speaking group had a greater understanding of the symbol. As one of the primary objectives of graphic and symbol design is to assist non-native speakers in understanding signage, the higher comprehension of the symbol by non-native speakers would point to the conclusion that the symbol be used in a design to increase this groups' understanding of the situation.

An additional concern of incorporating a work zone symbol into these designs was that the interpretation of this information would increase the needed viewing time for the graphic. Table 34 shows the viewing times for each of the options evaluated. This data indicates that there was very little difference in the viewing times and therefore very little concern that the symbol added extra load to the driver. In fact, the viewing time for the Spanish-speaking participants was actually lowered by the use of the symbol.

Table 34. Work Zone Scenario Viewing Times.

Scenario	Viewing Time (seconds)	
	English	Spanish
Symbol	11.8	11.5
Text	11.4	12.3

The other primary design feature evaluated for this topic was the ability of the participants to correctly identify the lane closure area. Researchers assessed this understanding by asking the participants to identify what lane(s) were available to drive in through the area.

Table 35 shows the comprehension percentages of participants who correctly identified that only the right lane was available in the work area.

Table 35. Work Zone Scenario Open Lane Comprehension.

Scenario	Lane Available Comprehension (%)	
	English	Spanish
Symbol	89	86
Text	90	86

Both language group participants were able to correctly identify that the right lane was the only lane available for each of the alternative designs. This high level of comprehension indicates that the graphic design used to identify closed lanes was easily interpreted by the participants.

The final element that researchers queried participants regarding was their likelihood to take an alternate route based on the information provided in the designs. Figure 53 and Figure 54 show the participants' responses for each graphic alternative.

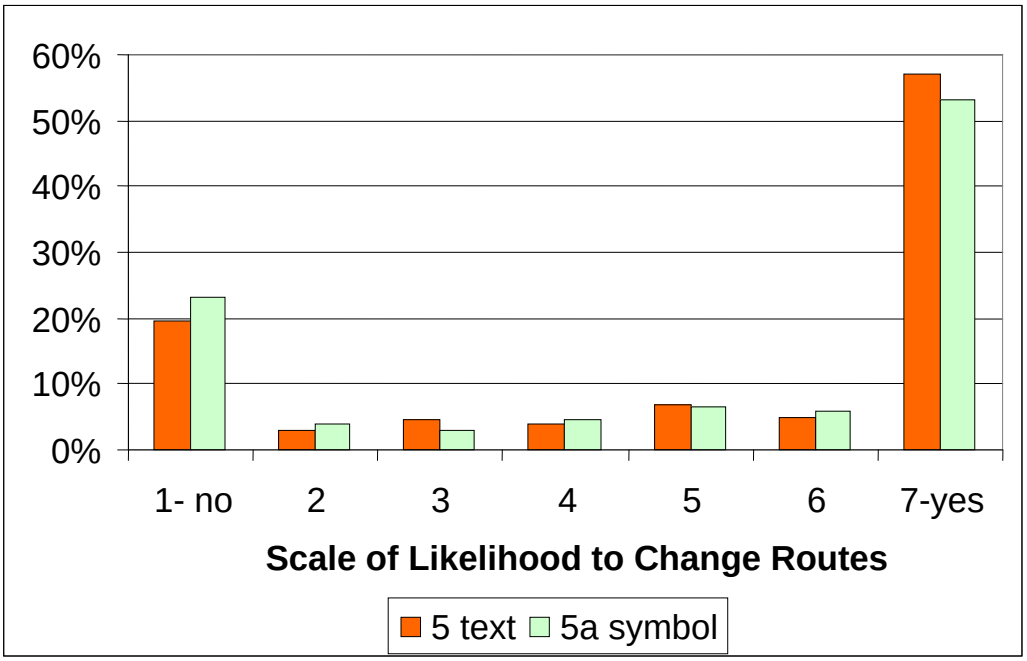


Figure 53. Work Zone Scenario Route Changes: English.

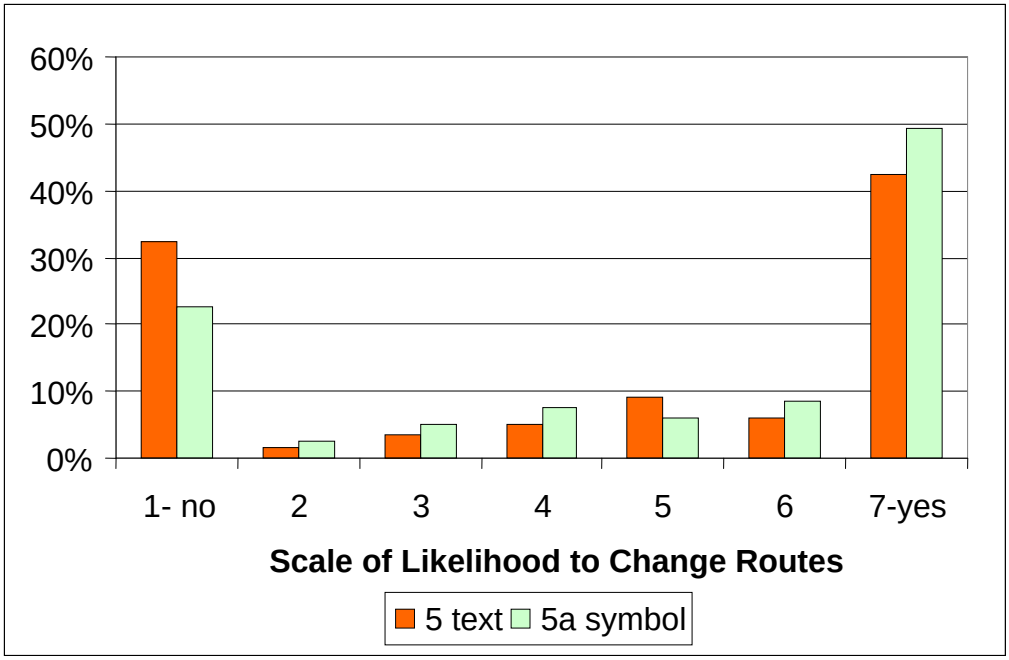


Figure 54. Work Zone Scenario Route Changes: Spanish.

When researchers evaluated which participants would change their routes, a direct relationship was identified between how well participants understood the situation and their likelihood of diverting to a different route. The more confident participants were in understanding what the graphic conveyed to them, the higher the percentage was of participants who thought they would choose to take a different route around that situation. Although diversion may not be the primary goal of these graphics, it does illustrate that drivers are not likely to change their behavior unless they have a clear and confident understanding of why they would choose to do so.

SUMMARY

The Level 2 Laboratory Study discussed in this chapter evaluated the ability of drivers to comprehend and use information presented in a graphical electronic format and compared this information to that of text-based DMS messages. Through this study, researchers identified elements within these signs that enhance or detract from this information. In the summary below researchers highlight the main findings within each topic area of the study.

- The information in text messages did not convey to participants how many lanes were available past an upcoming incident as effectively as graphic displays.
- The inclusion of delay on graphics did not have a significant impact on either expected delay or route decisions of the participants.
- Text (e.g., delay time, situation descriptors) should be avoided when designing graphic displays as this adversely affected the participants' ability to comprehend the messages in a timely manner.
- Route change decisions are primarily influenced by the number of lanes that are closed or blocked.
- Graphic and symbol displays had decreased viewing time as compared to equivalent text messages and should therefore be considered for use when portraying complex information to a driver.
- With regard to accident situations, the data indicate that participants used a combination of the information provided by a symbol representing an accident and roadway congestion levels to make decisions regarding severity.
- Accident severity was not the primary deciding factor for choosing to take an alternate route and additionally did not have a significant influence on delay expectations.
- Both text and symbol representations of "roadwork" were well understood by participants. However, as non-native speakers are a primary concern when considering graphics, the symbol for "roadwork" was better understood by the Spanish-speaking participants and should be used in graphic designs.
- Use of a symbol to indicate a work zone did not have a negative impact on viewing times (i.e., it did not significantly increase viewing times).
- The imagery used to represent closed lanes for a work area was well understood by participants.
- Participants' likelihood of changing routes was affected by their comprehension of the situation ahead. The lower the comprehension level was for a scenario, the less likely participants were to identify that they would take an alternate route.

CHAPTER 6: RECOMMENDATIONS AND GUIDANCE

DMSs have gained widespread acceptance as an effective means of relaying unexpected conditions to the motoring public. However, to this point all of the existing message design and display guidance focused on information presented in an alphanumeric format. As technology advances and the use of color and full-matrix image creation on these signs is more readily viable for use, the need to identify and define elements for graphic displays becomes critical. This project takes a step toward defining how graphic and symbol displays can improve or assist in communication with drivers. Researchers have also identified specific design elements that should or should not be used in graphic displays.

FORMAT GUIDANCE

The primary undertaking of this project was to identify how graphic and color displays could be used in the public right-of-way. Based on previous research and operations, researchers identified a wide variety of possible display formats that could be utilized for this type of DMS display. These formats ranged from all-encompassing regional map displays that provide an overview of a metropolitan area down to individual symbols that simply identify a specific problem immediately downstream of the driver's current location. The information presented in this section will look at overall guidance as it applies to the different formats that were evaluated during the human factors studies of this project.

Regional GRIP

The broadest information display possible in a full-color, full-matrix DMS is a regional view GRIP display. Figure 55 shows an example of this format examined during this project.

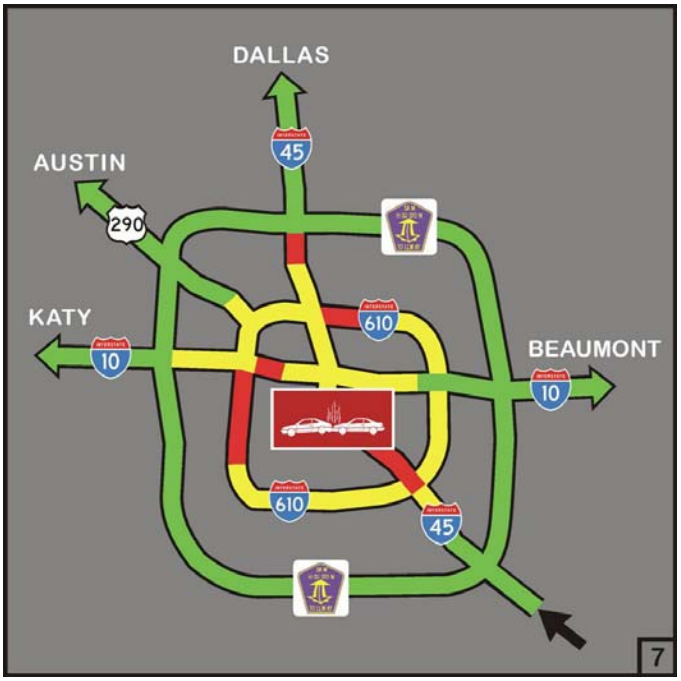


Figure 55. Regional GRIP Format Example.

This format is at the high end of the information scale in that it provides information to a driver about many different roadways in the metropolitan area. Inherent in representing this greater number of roadways is that the amount of detail possible for a given segment of roadway is limited. For example, the number of lanes or exits available throughout a segment cannot be reasonably represented. Information that is possible to present in this format includes:

- roadway layout and numbering,
- operating conditions through color congestion indicators, and/or
- accident locations through icons.

Obviously this type of regional view encompasses a great deal of information that drivers must try and dissect during their travel. Researchers have a significant concern that the amount of information presented through this format could overload drivers. Data collected in this project suggest that desired viewing times for a GRIP format display are significantly higher than for text or other graphic displays evaluated during this study. Researchers believe the amount of loading inherent in one of these displays is a direct product of the number of routes, incidents, and congestion detail provided on the sign. Researchers do not recommend using this type of format until more is known about the loading limitations of a regional GRIP display on DMS.

Partial – Regional GRIP

Theoretically, it is also possible to portray only a portion of the roadway network on a full-matrix DMS. For example, Figure 56 illustrates a display that was used during this study where only the eastern half of the Houston metropolitan area was included in the graphic. Although this representation would appear to contain significantly less information than the previous display, the desired viewing times by drivers were not significantly reduced when using this format. Therefore there still exists a major question of overloading a driver with this type of display that must be examined further before this type of display is a viable alternative.

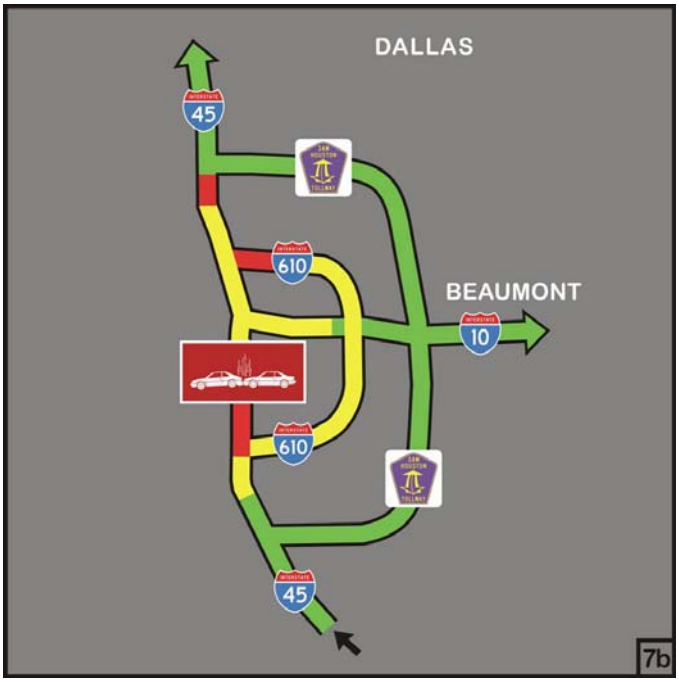


Figure 56. Partial – Region GRIP Format Example.

Immediate Area Display

A third formatting type possible with these types of DMSs is to portray just a localized portion of a roadway near a driver's current travel location. Note that this format allows for the display of lane-related information, a feature that was not realistic to include in the GRIP type displays. Figure 57 shows an example of the immediate area format that was evaluated during our studies.

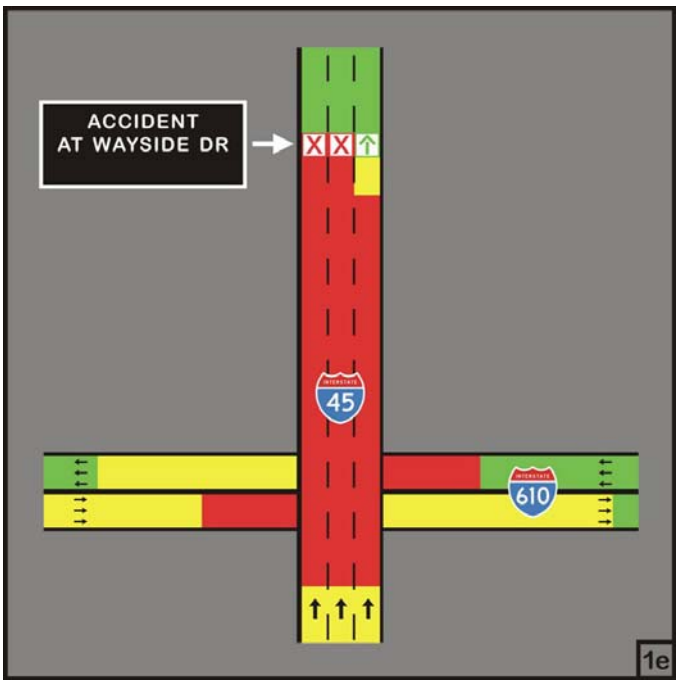


Figure 57. Immediate Area Format Example.

Overall, this type of display was interpreted well by drivers and does not appear to result in higher information loading than a text-based DMS message containing the problem descriptor, location, lanes affected, and effect on travel. In addition, the research suggests that these types of graphic displays may provide additional information benefits as compared to the equivalent text message. These benefits include the following key points.

- A graphic display improves the ability of drivers to identify the lanes available to drive in through a problem area. This identification may have a direct impact on both lane choice and route diversion driving decisions.
- The delivery of incident descriptor information (e.g., accident or work zone) through the use of graphic symbols improves the comprehension levels of non-native language drivers (e.g., a driver whose primary language is Spanish).
- The viewing time required for comprehension by a non-native speaker may be shortened as a result of the use of graphics and symbols.
- The use of graphics makes it possible to effectively illustrate unusual operational scenarios, such as HOV lanes or adjacent toll lanes, to a driver through the graphical representation of the roadway geometry, logos, shields, etc.

DESIGN ELEMENT RECOMMENDATIONS

In addition to the big-picture formatting issues discussed above, researchers also evaluated several smaller design element issues. The points below list different design elements recommended for use on graphic displays based on driver comprehension and preference. However it should be noted that many of these features still need to be validated with respect to current sign legibility capabilities for these elements.

- Use standard MUTCD format highway shields and signs when necessary to identify a roadway. This recommendation also holds true for using familiar toll facility logos and signing where appropriate.
- Place highway shields or road names on the roadway and not above or beside the graphic representation.
- When displaying traffic condition information using colors, researchers recommend the following coding: red = stop and go conditions, yellow = slow conditions, green = normal operating speed.
- Show arrows in all open lanes to reinforce that the lane is available for use past the problem area.
- Represent only one cross street or highway graphically on a given display. Give all other critical points, such as incident location or exit information, as text.
- When a toll facility is shown on the graphic display, drivers will assume they will need to pay a toll to use that road unless otherwise specifically stated.

There are also a few elements that were tested during the human factors studies for this project that were ineffective or nonessential for use on a graphic display. The following points are elements that should not be used on a graphic display.

- Color on a symbol background to indicate accident severity (i.e., major = red and minor = yellow) was not effective in conveying this information.
- Do not create a three-dimensional perspective of the area. It increased viewing time required by participants and did not improve overall comprehension of the situation.
- It is not necessary to illustrate highway exit ramps for drivers to know that they can divert or leave the current highway at major interchange locations.

- Do not illustrate multiple cross streets to better identify accident location as it appeared to overload the driver and reduce the effectiveness of the display.
- Inclusion of delay time on graphics displays did not significantly impact driver expectations of delay and therefore is not essential to the design of the display.

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APPENDIX A:
FOCUS GROUP PROTOCOL

Introduction to Focus Group

Hello, my name is _____. We are here today to conduct a group discussion for the Texas Department of Transportation (TxDOT). Before we start, if you have not turned in the **forms** you were given as you arrived, please turn them in now.

Our objective today is to obtain your opinions on the future use of large full color changeable message signs that are similar to the large scoreboards you see at major sporting events (for example the large screen you see at an Astros Game). Only a very small number of these large signs would be used in any one city. We are anticipating that these large signs would be installed near major freeway interchanges. We are asking for your help in designing messages that would be displayed on these signs.

You will notice that we are **recording** this session. The recording will be used as a backup to the notes being taken. In addition, it will allow us to concentrate on what you are saying in the group. I want to assure you that you will not be quoted by name. We would like you to remember that this discussion session is to obtain **your personal opinion**. We need to know what you think and how you personally feel about the topics we're going to be discussing. Beyond your own initial responses and impressions, I want you to feel free to respond to whatever anyone else says. Remember, you do not have to agree with us or with one another.

Now, I'd like to go over a few items before we begin.

- The role of the moderator is to **lead the discussion** and ensure that everyone in the group has the opportunity to share his/her point of view about the topics being discussed. The session should last about one and a half to two hours.
- Only one person should talk at a time because it becomes impossible to understand the tape when more than one person is talking. Also, if only one person is talking, it is much easier for the rest of us to focus on what that person is saying.
- Please refrain from having side conversations, as it tends to be very distracting.
- Please speak loud enough so that the tape recorder can pick up your comments.
- Please share your personal feelings about the topic, even if you have a negative comment or you disagree with others in the room. Remember, this discussion is being conducted to obtain your opinions.
- Please make your responses as clear and precise as possible.

First, I'd like to take just a few minutes and go around the room and have you introduce yourselves. Please state your first name only and tell us your experience with using information on changeable message signs as a commuter.

Scenario 1

In our first situation, I want you to assume that you are traveling northbound from Galveston on Interstate 45 (Gulf Freeway) heading to Conroe. There is a large color changeable message sign located before you reach Loop 610. The information that is displayed on the large sign is shown on this slide. (*Show Graph 1*).

1. What information is this sign telling you?
   a. What do the Xs and arrows here (*point to graphic*) mean to you? Is there a better way that closed or open lanes could be shown on the sign?
   b. What do the dashed lines here (*point to lane lines*) mean to you? Do you think it is necessary to show the lane lines in this type of graphic?
   c. What do you think these colors (point to sign) mean?
   d. Do you think this sign is easy or difficult to understand? Why? Do you have any suggestions to make this sign easier to understand?

2. Based on the information displayed on the sign would you change your route? Why or why not?
   a. Is there other information that you would need to make this decision?
   b. How would you show this information on the sign?

3. In Europe a symbol is often used on signs instead of the words to help drivers understand. Look at the symbols on this chart. (*Show slide of alternative symbols for accident.)*
   a. What do think symbol "a" means, symbol "b," etc.?
   b. Do all of the symbols have the same meaning?
   c. Which of the symbols do you think is best to illustrate an accident? Why?
   d. Can you think of a better symbol to represent an accident? (Hand out paper and ask participants to draw symbols.)

e. Would you change the symbols to show that a major accident has occurred? If yes, how? (*A major accident is one that would result in a delay of 45 minutes or more*.)
f. Do you think a symbol should be included in the sign we were just discussing instead of the word ACCIDENT (show graphic 1)? If yes, which symbol and where should it be placed? If no, why?
g. One option would be to show the symbol on the road. If this was done, should there be a symbol in each lane or only one symbol for the direction?

4. Here is another type of sign for the same situation. (*Show Graph 2*). What do these lines mean to you (*point to ramps*)? Can you think of another way to show ramps on this sign? If yes, what and how would you place them on the sign?
   a. Do the ramps make the sign easier or more difficult to understand than the previous example?
   b. Is it necessary to show the ramps on the sign? Why or why not?

5. Here is another way of showing information about the accident. (*Show Graph 3*) What do these lines mean on the sign (*point to cross-streets*)? Do you know of a better way to show cross-streets on the sign? If yes, what and where would you place them on the sign?
   a. Do cross-streets make the sign easier or more difficult to understand than the first example?
   b. Do cross streets help you make a decision about changing your route? Why or why not?
   c. Is it necessary to show the cross-streets on the sign? Why or why not?

6. Here is another way of showing information on a sign. (*Show Graph 4*) What do you think this sign means?
   a. Does this sign mean the same thing as the previous examples? If no, what is different?
   b. Is this sign easier or harder to understand than the previous examples? Why?

7. (Show all graphics)
   a. Here are the four signs that we just discussed. Which sign do you think provides you with the best information you would need? Why?

b. Which sign is the easiest to view and understand when you are diving at a high speed (70 mph)? Why?
c. Is there anything that we haven't discussed that you would change or add to make the signs easier for drivers to understand?

Scenario 2

I am now going to show you a slightly different situation that is at the same location. The information shown on this slide (*show Graph 5*) is displayed on the large sign.

1. What information is this sign telling you?
   a. What do the white bars/areas here (*point to graphic*) mean to you?
   b. Based on the information on the sign would you change your route? Why or why not?
   c. Is there other information that you would need to make this decision? If yes, how would you show this information on the sign?

2. As explained earlier, symbols are often used on signs instead of words to help drivers understand. Look at the symbols on this chart. (*Show slide of alternative symbols for roadwork.)*
   a. What do you think symbol "a" means, symbol "b," etc.?
   b. Do all of the symbols have the same meaning?
   c. Which of the symbols do you think best shows roadwork activity? Why?
   d. Can you think of a better symbol to represent roadwork? (Hand out paper and ask participants to draw symbols).
   e. Do any of these symbols seem more severe than the others? Would you change the symbols to show that the roadway has resulted in a major delay? If yes, how?
   f. Do you think it is important to have different symbols to indicate minor delays vs. major delays? What do you think is the difference between a minor delay and major delay?
   g. Do you think a symbol should be included in the sign we were just discussing instead of the word ROADWORK (*show graphic 5*)? If yes, which symbol and where should it be placed? If no, why?

h. One option would be to show the symbol on the road. If this was done, should there be a symbol in each lane or only one symbol for the direction?

Scenario 3

Again assume that you are traveling from Galveston on northbound Interstate 45 heading for Conroe. A major accident occurs on Interstate 45 before the I-610 Loop. There is a large color changeable message sign located on Interstate 45 before you reach the Sam Houston Tollway (Beltway 8). The information shown on this slide (*show Graph 6*) is displayed on the large sign.

1. What is this sign telling you?

2. We want to show that if you take the Sam Houston Tollway, you will have to pay a toll. Does this sign indicate that to you?
   a. Do you think the symbol for the Sam Houston Tollway is sufficient enough to let you know you would have to pay a toll? Why or why not?
   b. Is there any other word, phrase, or symbol that could be included on this sign to help drivers know they will have to pay a toll? (*Note to administrator: potential possibilities are TOLL, $.*)
   c. Where on the graphic would you include this word or symbol? Why?
   d. What does this symbol mean to you? (*Show a block T with a circle around it.)*
   e. Is this symbol (block T) easier or harder to understand than the other suggestions we have discussed?
   f. On the toll road, is it necessary to show the lane lines? If you placed a symbol or word on the road that meant tolls, should it be placed on each lane of the toll road or only once on the road? Why?

3. Now assume that when the major accident occurs on Interstate 45, there will be no tolls collected for drivers to use the Sam Houston Tollway. *(Show graphic 6 again.)*
   a. What would be the best word, phrase, or symbol to include on the sign so drivers will know there is no charge to use the toll road? (*Note to administrator: potential*

possibilities are FREE, NO TOLL, FREE LANES, ALL LANES OPEN, $ with a red slash thru it.)

b. Where on the graphic would you place this word/symbol? Why?

Scenario 4

Instead of the graphic you just saw before you reached Beltway 8, this figure was displayed on the sign (*show Graph 7*).

1. What information is this sign telling you?

2. Compared with the previous sign: (*Show both Graphs 6 and 7.*)
   a. Which sign do you like best? Why?
   b. What do you like/dislike about each sign?
   c. Which sign gives you the most or least information?
   d. If you were traveling at high speeds, which graphic do you think would be easier for a driver to understand? Why?
   e. How would you improve these signs?

Scenario 5

Now imagine yourself in Galveston and the city is advised to evacuate because of a major hurricane like Rita. You are traveling from Galveston on northbound Interstate 45. (*Show Graph 8.*) This is the message that is now displayed on the large sign during the evacuation.

1. What information is this sign providing to you?
   a. Based on the information on the sign, who would use the HOV lanes and who would use the main lanes? Why or Why not?
   b. Is this information provided enough for you to decide whether you would use the HOV lanes or the main lanes? What other information would you need, if any?
   c. What changes would you make to the design to help you determine what action you would make?
   d. What information is this sign providing you about the exits?

e. Is there a better way to show exit information? If yes, how?

2. Here is another sign for this type of evacuation situation. (*Show Graph 9.*) What does this graphic mean to you?
   a. Do you believe that this sign is easier or harder to understand than the previous example? Why?
   b. What changes would you make to the design?

Scenario 6

I want you to assume that you are driving on a new section of the eastbound Katy Freeway heading for downtown Houston. This section has both toll lanes and normal lanes running side by side. The information shown on this slide (*Show Graph 10.*) is displayed on a large changeable message sign.

1. What information is the sign telling you?

2. We want to tell drivers that they will have to pay a toll if they use the lanes on the left side.
   a. Is there a word, phrase, or symbol that could be included on this sign to help drivers know they will have to pay a toll when using these lanes?
   b. How would you include this phrase or symbol on the sign?
   c. (If different than scenario 3) The word, phrase or symbol that you chose is different than the one you selected to use in the previous example (Sam Houston Tollway); why did you select a different option?

3. Now assume a major accident has occurred and that there will be no charge for drivers to use the left lanes.
   a. What would be the best word, phrase, or symbol to include on the sign so drivers will know that there is no charge to use the toll lanes? (*Note to administrator: potential possibilities are FREE, NO TOLL, FREE LANES, ALL LANES OPEN, $ with a slash thru it.*)

b. (If different than scenario 3) The word, phrase or symbol that you chose is different than the one you selected to use in the previous example (Sam Houston Tollway); why did you select a different option?
c. Is there anything you would change about this sign to provide drivers with better information? If yes, what?

Scenario 7 (for truck drivers with Spanish as first language and other drivers)
Assume that you are driving from the valley on northbound Interstate 35 approaching San Antonio heading to a location north of Dallas.

1. What information is this sign telling you? (*Show Sign 11*.)

2. Based on this sign, what route (roads) would you take to get to Dallas?
   a. Is there other information that would help you to decide to use Loop 410, Interstate 10, and the 130 Toll Road toward Dallas?
   b. How would you include this information on the sign?
   c. What information influenced which route you decided to take? (*Note to moderator: prompt about tolls.*)
   d. Do you have any suggestions to improve the information displayed on this sign to make it easier for you to decide which route you should take (Loop 410, Interstate 10, and the 130 Toll Road toward Dallas)?

APPENDIX B:
LEVEL 1 LABORATORY STUDY SURVEY INSTRUMENT

Project 5256
Houston – Group A1

Section 1

We are looking toward the future with the development of large full color changeable message signs that are similar to the large scoreboards you see at major sporting events (for example the large screen you see at an Astros Game). Only a very small number of these large signs would be used in any one city. We are anticipating that these large signs would be installed before major freeway to freeway interchanges.

We are asking for your help in designing graphics/pictures that would be displayed on these signs. We want to make sure that you have as much information on the sign as necessary so that you and other drivers can make good decisions as to the actions you would take.

We want to start by having you review a map of the major roads in the Houston metropolitan area. *(Give the participant a map of the Houston area.)* I want you to assume that you are at this location in Houston *(Point to I-45 northbound [south of town] just upstream of Loop 610. Green Dot.)* and that you are traveling from Galveston on northbound Interstate 45 (Gulf Freeway) heading to Conroe. Take your time looking at the map and then let me know when you are familiar with the route you would take to get to Conroe.
What route would you take? _____

There is a large color changeable message sign located before you reach Loop 610. You will be viewing several of these signs one at a time that are displaying different types of information. When you press the space bar your first changeable message sign will appear on the laptop monitor. You will have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar ONCE to turn the message off. Then you will be asked questions about the information displayed on the changeable message sign. So try to remember as much of the information as possible. Do you have any questions?

Press the space bar to view the changeable message sign.

Test Message 1 (Sign 1) *is projected.* **Administrator Note as the sign appears: "I want to make sure that you realize that the entire picture shown on the screen is the sign, not just the black box. So look at the entire picture as if this is a sign you saw alongside the road as you are driving."**

Questions – Test Message 1 (Sign 1)

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. Where is the accident located? _____

   _____

3. Is it a major or minor accident? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

4. How many lanes are closed (open)? Closed _____ Open _____

5. What do the colors on the freeways mean? _____

   _____

   _____

6. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

   _____

   Why? _____

   _____

   _____

7. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

8. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

Review the map of the Houston area again. *(Give the participant the map of the Houston area.)* Remember that you are at this location *(Point to I-45 northbound [south of town] just upstream of Loop 610. Green Dot.)* and that you are traveling from Galveston on northbound Interstate 45 (Gulf Freeway) heading to Conroe. Take your time looking at the map and then let me know when you are ready to continue. *(When the participant is ready, proceed with the following.)*

When you press the space bar the large sign with a different display will appear. Remember, you have control over how long you view the message. So, the instant you have read and understand the message, you will need to press the space bar to turn the message off. Then you will be asked questions about the information in the message. So try to remember the information in the message.

Press the space bar to view the sign.

*At the appropriate time, **Sign 3** is projected.*

Questions – Sign 3

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. How many lanes are closed (open)? Closed _____ Open _____

3. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

   _____

   Why? _____

   _____

   _____

4. Where is the accident located? _____

   _____

   _____

5. What do the colors on the freeways mean? _____

   _____

   _____

6. Is it a major or minor accident? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

7. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

8. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

9. What other information do you need if any to determine the route you would take? _____

   _____

   _____

Press the space bar to view a different sign.

At the appropriate time, ***Sign 1i*** *is projected.*

Questions – Sign 1i

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. What do the colors on the freeways mean? _____

   _____

   _____

3. How many lanes are closed (open)? Closed _____ Open _____

4. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

   _____

   Why? _____

   _____

   _____

5. Where is the accident located? _____

   _____

   _____

6. Is it a major or minor accident? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

7. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

8. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

9. What other information do you need if any to determine the route you would take? _____

   _____

   _____

   _____

Press the space bar to view another sign.

At the appropriate time, ***Sign 1a*** *is projected.*

Questions – Sign 1a

1. What information is this sign giving you? _____

   _____

   _____

   _____

   _____

2. How many lanes are closed (open)? Closed _____ Open _____

3. What do the colors on the freeways mean? _____

   _____

   _____

4. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

   _____

   Why? _____

   _____

   _____

5. Is it a major or minor event (accident)? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

6. Where is the accident located? _____

   _____

7. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

8. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

9. What other information do you need if any to determine the route you would take? _____

   _____

   _____

   _____

Press the space bar to view another sign.

At the appropriate time, ***Sign 1e*** *is projected.*

Questions – Sign 1e

1. What information is this sign giving you? _____

   _____

   _____

   _____

   _____

2. Is it a major or minor event (accident)? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

3. What do the colors on the freeways mean? _____

   _____

   _____

4. Where is the accident located? _____

   _____

5. How many lanes are closed (open)? Closed _____ Open _____

6. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

   _____

   Why? _____

   _____

   _____

7. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

8. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

   _____

9. What other information do you need if any to determine the route you would take? _____

   _____

   _____

   _____

Press the space bar to view another sign.

*At the appropriate time, **Sign 4a** is projected.*

Questions – Sign 4a

1. What information is this sign giving you? _____

   _____

   _____

2. What does the white area (road) represent? _____

   _____

   _____

3. What do the colors on the freeways mean? _____

   _____

   _____

4. Where is the accident located? _____

   _____

5. Is it a major or minor event (accident)? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

6. How many lanes are closed (open)? Closed _____ Open _____

7. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

   _____

   Why? _____

   _____

   _____

8. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

9. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

10. What other information do you need if any to determine the route you would take? _____

_____

_____

_____

Press the space bar to view the sign with a different display.

At the appropriate time, ***Sign 1d*** *is projected.*

Questions – Sign 1d

1. What information is this sign giving you? _____

_____

_____

_____

_____

2. There was a symbol (picture) on the left side of the sign, what did that mean to you? _____

_____

_____

3. Where is the event (accident) located? _____

_____

4. How many lanes are closed (open)? Closed _____ Open _____
5. If you were traveling in the right lane, how would you expect traffic to be moving (if at all)?

_____

Why? _____

_____

_____

6. Is it a major or minor event (accident)? ☐ Major ☐ Minor
   How did you know? _____

_____

_____

7. What do the colors on the freeways mean? _____

_____

_____

8. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

9. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? _____

   _____

   Why? _____

   _____

   _____

10. What other information do you need if any to determine the route you would take? _____

    _____

Comparisons: The next time you press the space bar, you will see two signs shown side-by-side. As soon as the signs appear, I will ask you questions about the signs while they are still on the screen. So do not press the space bar again until we are finished with the questions.

Press the space bar when you are ready.

*At the appropriate time, **Sign 1i** and **Sign 1a** are projected side-by-side.*

Questions – Comparison 1i &1a

1. Which sign do you prefer? ☐ 1i (left) ☐ 1a (right)
   Why? _____

   _____

   _____

2. Is one sign giving you more information than the other sign? ☐ 1i (left) ☐ 1a (right) ☐ no
   If yes, what additional information is it providing? _____

   _____

   _____

3. If you were driving in the right lane, is there a difference in how traffic is moving between the two signs? ☐ Yes ☐ No

   If yes, what is the difference? _____

   _____

   _____

4. Which sign does a better job in telling drivers that the right lane is open to traffic?
   ☐ 1i (left) ☐ 1a (right) Why? _____

_____

_____

Again, when you press the space bar, you will see two signs side-by-side. As soon as the signs appear, I will ask you questions about the signs.

Press the space bar when you are ready.

*At the appropriate time, **Sign 1a** and **Sign 1b** are projected side-by-side.*

Questions – Comparison 1a & 1b

1. Which sign do you prefer? ☐ 1a (left) ☐ 1b (right)
   Why? _____

_____

_____

You will again see two signs side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 1e** and **Sign 1f** are projected side-by-side.*

Questions – Comparison 1e & 1f

1. Is one sign giving you more information than the other sign? ☐ 1e (left) ☐ 1f (right) ☐ No
   If yes, what additional information is it providing? _____

_____

_____

2. Which sign do you prefer? ☐ 1e (left) ☐ 1f (right)
   Why? _____

_____

_____

This time, you will now see FOUR signs. Press the space bar when you are ready.

*At the appropriate time, **Sign 1e, Sign 1f**, **Sign 1g**, and **Sign 1h** are projected.*

Questions – Comparison 1e, 1f, 1g, and 1h

1. Which sign do you prefer? ☐ 1e ☐ 1f
   ☐ 1g ☐ 1h
   Why? _____

_____

_____

_____

_____

2. Looking at the right lane, what is Sign 1e telling you? _____

   _____

   Sign 1f? _____

   _____

   Sign 1g? _____

   _____

   Sign 1h? _____

   _____

3. Do all of these signs mean the same thing to you? ☐ Yes ☐ No

   If no, what is the difference?_____

   _____

   _____

4. Rank these four signs from best to worst with 1 being the best and 4 being the worst.

   1e _____ 1f _____

   1g _____ 1h _____

Again you will see two signs side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 1e** and **Sign 2** are projected side-by-side.*

Question – Comparison 1e and 2

1. Which sign do you prefer? ☐ 1e (left) ☐ 2 (right)

   Why? _____

   _____

   _____

Again you will see two signs side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 2** and **Sign 4a** are projected side-by-side.*

Question – Comparison 2 & 4a

1. Which sign do you prefer? ☐ 2 (left) ☐ 4a (right)

   Why? _____

   _____

   _____

Symbols are often used on signs instead of the words to help drivers understand the signs. When you press the space bar you will see some symbols. I will then ask you some questions.

Press the space bar when you are ready.

*At the appropriate time, **Crash Symbols** are projected.*

Questions – Comparison Crash Symbols

1. What do you think Symbol "C-1" means? _____

   _____

   Symbol "C-2"? _____

   _____

   Symbol "C-3"? _____

   _____

   Symbol "C-4"? _____

   _____

2. Do they all have the same meaning? ☐ Yes ☐ No
   If no, what is the difference to you? _____

   _____

   _____

3. Which of the symbols do you think indicates an accident the best? ☐C-1 ☐C-2 ☐C-3 ☐C-4

   Why? _____

   _____

   _____

4. Would you change the symbols to show that a major accident has occurred? ☐ Yes ☐ No
   If yes, how? _____

   _____

   _____

Again you will see two signs side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 1d and Sign 1c** are projected.*

Questions – Comparison 1d & 1c

1. Is the information given to you different between the two signs? ☐ Yes ☐ No
   If yes, what is the difference? *(Make sure that the participant does not merely answer that one sign has red and the other has yellow.)* _____

   _____

   _____

2. Do the red and yellow colors of the boxes mean different things to you? ☐ Yes ☐ No
   If yes, what? _____

   _____

   _____

3. Would you change anything about the message to indicate a major or minor accident?
   ☐ Yes ☐ No If yes, what? _____

   _____

   _____

Again you will see two signs side-by-side; press the space bar when you are ready.

At the appropriate time, ***Sign 1b and Sign 1c*** *are projected.*

Question – Comparison 1b & 1c

1. Which sign do you prefer? ☐ 1b (left) ☐ 1c (right)
   Why? _____

   _____

   _____

Again you will see two signs side-by-side; press the space bar when you are ready.

At the appropriate time, ***Sign 1c' and Sign 1c*** *are projected.*

Question – Comparison 1c'& 1c

1. Which sign do you prefer? ☐ 1c'-street (left) ☐ 1c-words (right)
   Why? _____

   _____

   _____

Again you will see two signs side-by-side; press the space bar when you are ready.

At the appropriate time, ***Sign 3A and Sign 3*** *are projected.*

Question – Comparison 3A and 3

1. Which sign do you prefer? ☐ 3a (left) ☐ 3 (right)
   Why? _____

   _____

   _____

Again you will see two signs side-by-side; press the space bar when you are ready.

At the appropriate time, ***Sign 5 and Sign 5a*** *are projected.*

Questions – Comparison 5 and 5a

1. Which sign do you prefer? ☐ 5 (left) ☐ 5a (right)
   Why? _____

   _____

   _____

2. What does the orange and black area on the left two lanes of this sign mean to you? _____

   _____

   _____

3. What does the symbol (picture) in the black box mean to you? _____

   _____

   _____

4. Would you change anything about the sign to better represent a roadwork area? ☐Yes ☐ No

   _____

   _____

   _____

SECTION 2: GRIPs

We want to start by having you again review a map of the major roads in the Houston metropolitan area. *(Give the participant a map of Houston area.)* I want you to assume that you are at this location *(Point to I-45 northbound [south of town] just before the Sam Houston Tollway.)* and that you are traveling from Galveston on northbound Interstate 45 (Gulf Freeway) heading to Conroe. Take your time looking at the map and then let me know when you are ready to continue. What route would you take?

_____

_____

There is a large color changeable message sign located before you reach the Sam Houston Tollway. You will be viewing the signs one at a time that are displaying different types of information. When you press the space bar your first sign will appear on the laptop monitor. You will have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar to turn the message off. Then you will be asked questions about the information displayed on the changeable message sign. So try to remember the information in the message. Do you have any questions?

Press the space bar to view the changeable message sign.

At the appropriate time, ***Test Message 3 (Sign 7')*** *is projected.*

Questions – Test Message 3 (Sign 7')

1. What information is this sign giving you? _____

   _____

   _____

2. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

3. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? Why? _____

   _____

   _____

We want to review the map of the Houston area again. *(Give the participant the map of the Houston area.)* Remember that you are at this location in Houston *(Point to I-45 northbound [south of town] just before the Sam Houston Tollway. Pink Dot)* and that you are traveling from Galveston on northbound Interstate 45 (Gulf Freeway) heading to Conroe. When you are ready, let me know and we will continue. *(When the participant is ready, proceed with the following.)*

When you press the space bar the large sign with a different display will appear. Remember, you have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar to turn the message off. Then you will be asked questions about the information in the message. So try to remember the information in the message.

Press the space bar to view the sign.

At the appropriate time, ***Sign 7*** *is projected.*

Questions – Sign 7

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. Where is the accident located? _____

   _____

3. Is it a major or minor accident? ☐ Major ☐ Minor
   How did you know? _____

   _____

   _____

4. What do the colors on the freeways mean? _____

   _____

   _____

5. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

6. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? Why? _____

   _____

   _____

7. What other information do you need to determine what route you would take?

   _____

   _____

   _____

Press the space bar to view different sign.

At the appropriate time, ***Sign 7b*** *is projected.*

Questions – Sign 7b

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. Where is the accident located? _____

   _____

3. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

4. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? Why? _____

5. What other information do you need if any to determine what route you would take?

The next time you press the space bar, you will see two signs shown side-by-side. As soon as the signs appear, I will ask you questions about the signs while they are on the screen.

Press the space bar when you are ready.

*At the appropriate time, **Sign 7a** and **Sign 7b** are projected side-by-side.*

Question – Comparison 7a and 7b

1. Which sign do you prefer? ☐ 7a (left) ☐ 7b (right)
   Why?

Again you will see two signs side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 7a** and **Sign 7''** are projected side-by-side.*

Questions – Comparison Signs 7a and 7''

1. What is the difference between the two signs?

2. Would this difference change your decision on what route to take to Conroe? ☐ Yes ☐ No
   Why and what route would you take?

SECTION 3: Tollway Cross Highway

Assume again that you are traveling from Galveston on northbound Interstate 45 (Gulf Freeway) heading to Conroe and you are approaching Beltway 8 (Sam Houston Tollway). There is a large color changeable message sign located before you reach Beltway 8 (Sam Houston Tollway). You will again be viewing different large full color changeable message signs one at a time that are displaying various types of information. When you press the space bar your first changeable message sign will appear on the laptop monitor. You will again have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar to turn the message off. Then you will be asked questions about the information displayed

on the changeable message sign. So try to remember the information in the message. Do you have any questions?

Press the space bar to view the sign.

*At the appropriate time, **Sign 6** is projected.*

Questions – Sign 6

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. Where is the accident located? _____

   _____

3. How many lanes are closed (open)? Closed _____ Open _____
4. What route would you take to Conroe? _____

   _____

   Why? _____

   _____

   _____

5. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? Why? _____

   _____

6. If you change routes and use the cross highway shown on the sign, will you have to pay a toll? ☐ Yes ☐ No

   How did you know? _____

   _____

   _____

Press the space bar to view a different sign.

*At the appropriate time, **Sign 6a** is projected.*

Questions – Sign 6a

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. What route would you take to Conroe? _____

   Why? _____

3. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? Why? _____

4. If you change routes and use the cross highway shown on the sign, will you have to pay a toll? ☐ Yes ☐ No

   How did you know? _____

Press the space bar to view a different sign.

At the appropriate time, ***Sign 6b*** *is projected.*

Questions – Sign 6b

1. What information is this sign giving you? _____

2. What route would you take to Conroe? _____

   Why? _____

3. *(if they would take I-45 through Houston)* Assume that you decided to take an alternate route to Conroe, what route would you take? Why? _____

4. If you change routes and use the cross highway shown, will you have to pay a toll?
   ☐ Yes ☐ No ☐ Only after SH225 Why or why not? _____

   _____

   _____

5. If no toll is being collected, how far can you drive before you have to start paying tolls again? _____

   _____

   _____

6. Is there other information that you would like to see on the sign when no toll is charged? ___

   _____

   _____

SECTION 4: HOV Lanes

Now place yourself in Galveston and the city is advised to evacuate because of a major hurricane like Rita. You are traveling from Galveston on northbound Interstate 45 and are approaching the Sam Houston Tollway. *(Point to I-45 northbound [south of town] just upstream of the Sam Houston Tollway.)* You will again be viewing a large full color changeable message sign. When you press the space bar your first sign will appear on the laptop monitor. You will again have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar to turn it off. Then you will be asked questions about the information displayed on the changeable message sign. So try to remember the information in the message. Do you have any questions?

Press the space bar to view the sign.

*At the appropriate time, **Sign 8** is projected.*

Questions – Sign 8

1. What information is this sign giving you? _____

   _____

   _____

2. There was a lane on the left separated from the main lanes by a gray area; can you drive in that lane? ☐ Yes ☐ No

   Why or why not? _____

   _____

   _____

   If yes, would you drive in that lane? ☐ Yes ☐ No

   Why or why not? _____

   _____

   _____

3. What information would you like to have that is not shown on the sign to help you make the decision of what lane you would use? _____

_____

_____

The next time you press the space bar, you will see THREE signs shown side-by-side. As soon as the signs appear, I will ask you questions about the signs while they are on the screen.

Press the space bar when you are ready.

*At the appropriate time, **Sign 8, Sign 8a,** and **Sign 8b** are projected side-by-side.*

Question – Comparison 8, 8a and 8b

1. Which sign do you prefer? ☐ 8 ☐ 8a ☐ 8b

   Why? _____

_____

_____

_____

SECTION 5: ADJACENT TOLL LANES

Assume now that you are traveling from Katy on eastbound Interstate 10 heading toward downtown and you are again approaching the Sam Houston Tollway. *(Point to I-10 eastbound [west of town] just upstream of the Sam Houston Tollway. Yellow Dot)*

There is a large color changeable message sign located before you reach the Sam Houston Tollway. You will again be viewing a few different signs. When you press the space bar your first sign will appear. You will again have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar to turn the message off. Then you will be asked questions about the information displayed on the changeable message sign. So try to remember the information in the message. Do you have any questions?

Press the space bar to view the sign.

*At the appropriate time, **Sign 10** is projected.*

Questions – Sign 10

1. What information is this sign giving you? _____

_____

_____

_____

2. Where is the accident located? *(As part of this response we need to get street name and main or toll lanes.)* _____

_____

3. How many lanes are closed (open)? Closed _____ Open _____
4. For this situation, what action would you take? _____

   Why? _____

_____

_____

5. Are you allowed to drive in the left set of lanes? ☐ Yes ☐ No
   Why or why not? _____

_____

_____

6. Would you have to pay a toll to drive in the left set of lanes? ☐ Yes ☐ No
   Why or why not? _____

_____

_____

7. Who is permitted to drive in the left set of lanes? _____

_____

_____

8. On the left lanes, there was a symbol/box that said "TxTag"; what did that mean to you?

_____

_____

_____

Press the space bar to view a different sign.

At the appropriate time, ***Sign 10a*** *is projected.*

Questions – Sign 10a

1. What information is this sign giving you? _____

_____

_____

_____

2. Where is the accident located? *(As part of this response we need to get street name and main or toll lanes.)* _____

_____

3. How many lanes are closed (open)? Closed _____ Open _____

4. For this situation, what action would you take? Why? _____

_____

_____

5. Are you allowed to drive in the left set of lanes? ☐ Yes ☐ No
   How did you know? _____

_____

_____

6. Would you have to pay a toll to drive in these lanes? ☐ Yes ☐ No
   How did you know? _____

_____

_____

7. Who is permitted to drive in the left set of lanes? _____

_____

_____

The next time you press the space bar, you will see THREE signs shown side-by-side that are designed to give the same information. In this situation, the accident has caused severe traffic congestion and the toll lanes are being opened for all vehicles without having to pay a toll. As soon as the signs appear, I will ask you questions about the signs while they are on the screen.

Press the space bar when you are ready.

*At the appropriate time, **Sign 10a, Sign 10c,** and **Sign 10d** are projected side-by-side.*

Questions – Comparison 10a, 10c, and 10d

1. Which sign do you prefer? ☐ 10a ☐ 10c ☐ 10d
   Why? _____

_____

_____

2. Is there a better way to give information that if you take the left toll lanes, you do not have to pay a toll? _____

_____

_____

SECTION 6: TRUCK ROUTE

Assume now that you are traveling on northbound I-37 toward San Antonio heading to a location north of Dallas. *(Show San Antonio Map)* There is a large color changeable message sign located before you reach San Antonio. You will be viewing a few different signs one at a time. When you press the space bar your first sign will appear. You will again have control over how long you view the message. So, the instant you have read the message, you will need to press the space bar to turn the message off. Then you will be asked questions about the information displayed on the sign. Do you have any questions?

Press the space bar to view the sign.

*At the appropriate time, **Test Message (Sign 12)** is projected.*

Questions – Test Message (Sign 12)

1. What information is this sign giving you? _____

   _____

   _____

   _____

2. What route would you take to get to your destination north of Dallas? _____

   _____

   Why? _____

   _____

   _____

3. What information helped you decide which route to take? _____

   _____

   _____

Press the space bar when you are ready to view a different sign.

*At the appropriate time, **Sign 12a** is projected.*

Questions – Sign 12a

1. What information is this sign giving you? _____

   _____

   _____

2. What do the colors on the freeways mean? _____

   _____

   _____

3. What route would you take to get to your destination north of Dallas? _____

   _____

   Why? _____

   _____

   _____

   _____

4. What information influenced which route you decided to take? _____

   _____

   _____

The next time you press the space bar, you will see THREE signs shown side-by-side that are designed to give the same information. As soon as the signs appear, I will ask you questions about the signs.

Press the space bar when you are ready.

At the appropriate time, ***Sign 12a, Sign 12b,*** *and* ***Sign 12c*** *are projected side-by-side.*

Questions – Comparison 12a, 12b, and 12c

1. Which sign do you prefer? ☐ 12a ☐ 12b ☐ 12c

   Why? _____

   _____

   _____

2. Rank these three signs from best to worst with 1 being the best and 3 being the worst.

   12a _____ 12b _____

   12c _____

3. Is there other information that you would include on the sign to improve the information and/or to encourage drivers to use Loop 410, Interstate 10, and the 130 Toll Road toward Dallas? *(point to route)* _____

   _____

   _____

   How would you include this information on the sign? _____

   _____

   _____

The next time you press the space bar, you will see TWO signs shown side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 12c** and **Sign 12d** are projected side-by-side.*

Question – Comparison 12c & 12d

1. Which sign do you prefer? ☐ 12c (left) ☐ 12d (right)
   Why? _____

   _____

   _____

The next time you press the space bar, you will see THREE signs shown side-by-side; press the space bar when you are ready.

*At the appropriate time, **Sign 12d, Sign 12f**, and **Sign 12e** are projected side-by-side.*

Questions – Comparison 12d, 12f, and 12e

1. Which sign do you prefer? ☐ 12d ☐ 12f ☐ 12e

   Why? _____

   _____

   _____

2. Rank these three signs from best to worst with 1 being the best and 3 being the worst.

   12d _____ 12f _____

   12e _____

That completes our study. Thank you for your participation.

APPENDIX C:
LEVEL 2 LABORATORY STUDIES SURVEY INSTRUMENTS

English Survey Example:

Demographics:

Gender: ❒ male ❒ female

Age: ❒ < 25 ❒ 25-54 ❒ 55+

Education: ❒ some high school ❒ high school graduate
❒ some college ❒ college graduate

We are looking at different types of information that could be provided to drivers to help them in making driving decisions while they are traveling on local highways. [*show examples*] These are some examples of the types of information or pictures that you may see during this study. This information would be displayed on large electronic signs along the highway, much like you see the large electronic word signs now. For the picture sign (*point to graphic display*), I want you to realize that the entire picture is what you will see on the sign along the road while you are driving (not just the black box).

Before we start, I want you to look at a map of the area (*give participant local map and blow up*). I want you to assume that you are at this location in Houston (*point to Green Dot*) and that you are traveling to Conroe on northbound Interstate 45. (*Point to blow up map)* You can see that this is a closer view of the area that you are currently traveling in.

1. How often do you drive in this area of Houston? (circle one)

Daily few times a week Once a week Once a month Few times a year yearly never

When we begin, you will press the space bar and the first sign will appear on the laptop monitor. For this part of the study, you will have control over how long you view the message. So, the instant you understand the situation and know what you would do, you will need to press the space bar again to turn the image off. Then you will be asked questions about the information displayed on the screen. While you are looking at the message on the computer, I will be timing how long it is on the screen, but don't feel that you have to rush. Take all the time you need to understand the information. Do you have any questions?

Test Message: No color, travel time. Time: _____seconds

Questions:

1. Given the information you just saw, would you change routes to go to your destination?
Yes No

2. How much extra time do you expect your trip to take based on the information you just saw?
< 10 minutes 11-20 minutes 21-30 minutes 31-40 minutes More than 40 minutes

We will repeat this process for the next few images. Do you have any questions? If no, press the spacebar to begin the next display.

Part 1: Unlimited Viewing Time

Graphic 1m: 1 lane blocked, no delay time Time: _____seconds

Questions:

1. Given the information you just saw, how likely are you to leave the highway and take a different path to your destination? *Using a scale where 1 means you would definitely not change routes, and 7 meaning you definitely would change.*

Definitely Will Not						Definitely will
1	2	3	4	5	6	7

2. What lane(s) could you drive in through this area? Left Center Right

3. How much extra time do you expect your trip to take based on the information you just saw?

< 10 minutes 11-20 minutes 21-30 minutes 31-40 minutes More than 40 minutes

Press the space bar to see the next sign.

Text Message 1: 2 lanes blocked, with delay time Time: _____seconds

Questions:

1. Given the information you just saw, how likely are you to leave the highway and take a different path to your destination? *Using a scale where 1 means you would definitely not change routes, and 7 meaning you definitely would change.*

Definitely Will Not						Definitely will
1	2	3	4	5	6	7

2. What lane(s) could you drive in through this area? Left Center Right

3. How much extra time do you expect your trip to take based on the information you just saw?

< 10 minutes 11-20 minutes 21-30 minutes 31-40 minutes More than 40 minutes

Press the space bar to see the next sign.

Graphic 1d/L: C-4 symbol with long congestion area Time: _____seconds

Questions:

1. Given the information you just saw, how likely are you to leave the highway and take a different path to your destination? *Using a scale where 1 means you would definitely not change routes, and 7 meaning you definitely would change.*

Definitely Will Not						Definitely will
1	2	3	4	5	6	7

2. What event (or problem) was occurring on this road?
   Accident Construction other_____

3. Was this a major or minor (event) problem? Major minor

4. How much extra time do you expect your trip to take based on the information you just saw?
< 10 minutes 11-20 minutes 21-30 minutes 31-40 minutes More than 40 minutes

Press the space bar to see the next sign.

Graphic 5: Work Zone Text Time: _____seconds

Questions:

1. What event (or problem) was occurring on this road?
   Accident Construction other_____

2. What lane(s) could you drive in through this area? Left Center Right

3. Given the information you just saw, how likely are you to leave the highway and take a different path to your destination? *Using a scale where 1 means you would definitely not change routes, and 7 meaning you definitely would change.*

Definitely Will Not						Definitely will
1	2	3	4	5	6	7

Part 2: Limited Time

For the final image we are going to change the format used to display the graphic. This time, the image will appear for a limited amount of time. It will stay on the screen for a few seconds and then will automatically turn off (you do not need to touch any buttons during this process). You will then be asked questions about the information in the message. Do you have any questions?

Start Example of timing change. No questions will be asked following example.

Press the space bar when you are ready to begin. Remember you will not need to touch the space bar again. The image will turn off by itself after a few seconds.

Text 4: 1 lanes blocked, no delay time

Questions:

1. Given the information you just saw, how likely are you to leave the highway and take a different path to your destination? *Using a scale where 1 means you would definitely not change routes, and 7 meaning you definitely would change.*

Definitely Will Not						Definitely will
1	2	3	4	5	6	7

2. What lane(s) could you drive in through this area? Left Center Right

3. How much extra time do you expect your trip to take based on the information you just saw?
< 10 minutes 11-20 minutes 21-30 minutes 31-40 minutes More than 40 minutes

Spanish Survey Example:
Participant # _____ Date _____
Researcher: _____ Survey # 1

Demográfico:
Género: ❒ masculino ❒ hembra

Edad: ❒ < 25 ❒ 25-54 ❒ 55+

Educación: ❒ algún escuela ❒ graduado de instituto
❒ algún colegio ❒ graduado de colegio

Miramos los tipos diferentes de información que podría ser proporcionada a conductores para ayudarlos a hacer manejar las decisiones mientras ellos viajan en carreteras locales. [los ejemplos de la exposición]. Estos son algunos ejemplos de los tipos de información o retratos que usted puede ver durante este estudio. Esta información sería demostrada en signos electrónicos grandes por la carretera, mucho que quiere usted ve los signos electrónicos grandes de palabra ahora. Para el signo del retrato (el punto al despliegue gráfico), quiero que usted dése cuenta de que el retrato entero es lo que usted verá en el signo por el camino mientras usted maneja (no apenas la caja negra).

Antes que empezemos, quiero que usted mire un mapa del área (de al participante mapa). Quiero que usted asuma que usted está en esta ubicación en San Antonio (punte al Punto Verde), en I-37 poco antes de que usted alcanze I-410 lazo, y que usted viaja a Kerrville (al norte de San Antonio). (*punte al mapa*) Usted puede ver que esto es una vista más cerca del área en que usted viaja actualmente.

2. ¿Con qué frecuencia maneja usted en esta área de San Antonio? (rodee uno)

Diario Pocos veces una semana Una vez a la semana Una vez al mes
Pocos tiempos al año Anuales Nunca

Cuándo nosotros empezamos, usted apretará el espaciador y el primer signo aparecerá en el monitor de ordenador portátil. Para esta parte del estudio, usted tendrá el control sobre cuán largo usted ve el mensaje. Así, el instante usted entiende la situación y sabe lo que usted haría, usted necesitará apretar el espaciador otra vez para apagar la imagen. Entonces usted será hecho preguntas acerca de la información demostrada en la pantalla. Mientras usted mira el mensaje en la computadora, yo seré tiempo cuán largo está en la pantalla, pero no se siente que usted tiene que apresurarse. Tome todo el tiempo usted necesita entender la información. ¿Tiene usted alguna pregunta?

Mensaje de pruebe: Ningún color, viaja tiempo. Tiempo: _____ segundos
Preguntas:

3. Dada la información que usted acaba de ver, le hace cambia las rutas para ir a su destino?
   Si No

4. Cómo tiempo mucho más extra le hace espera que su viaje tome basado en la información que usted acaba de ver?

< 10 minutos 11-20 minutos 21-30 minutos 31-40 minutos Más de 40 minutos
Repetiremos este proceso para las próximas pocas imágenes, tiene usted alguna pregunta? Si no, aprieta la barra espaciadora para empezar el próximo despliegue.

Parte 1: El Tiempo Limitado que Ve

Graphic 1m: 1 la senda bloqueó, ningún tiempo de demora Tiempo: _____segundos

Preguntas:

4. Dada la información que usted acaba de ver, que probable es que usted salga de la carretera y tome un sendero diferente a su destino? *Utilizar una escala donde 1 medios usted definitivamente no cambiaría las rutas, y 7 significado que usted cambiaría definitivamente.*

Hace definitivamente no						Hace definitivamente
1	2	3	4	5	6	7

5. Qué senda (sendas) puede usted manejar por esta área? Izquierdo Central Derecho

6. Cómo tiempo mucho más extra le hace espera que su viaje tome basado en la información que usted acaba de ver?

< 10 minutos 11-20 minutos 21-30 minutos 31-40 minutos Mas de 40 minutos

Apriete el espaciador para ver el próximo signo.

Mensaje de texto 1: 2 sendas bloquearon, con tiempo de demora Tiempo: _____segundos

Preguntas:

4. Dada la información que usted acaba de ver, que probable es que usted salga de la carretera y tome un sendero diferente a su destino? *Utilizar una escala donde 1 medios usted definitivamente no cambiaría las rutas, y 7 significado que usted cambiaría definitivamente.*

Hace definitivamente no						Hace definitivamente
1	2	3	4	5	6	7

5. Qué senda (sendas) puede usted manejar por esta área? Izquierdo Central Derecho

6. Cómo tiempo mucho más extra le hace espera que su viaje tome basado en la información que usted acaba de ver?

< 10 minutos 11-20 minutos 21-30 minutos 31-40 minutos Más de 40 minutos

Apriete el espaciador para ver el próximo signo.

Graphic 1d/L: C-4 el símbolo con área larga de congestión Tiempo: _____segundos

Preguntas:

5. Dada la información que usted acaba de ver, que probable es que usted salga de la carretera y tome un sendero diferente a su destino? *Utilizar una escala donde 1 medios usted definitivamente no cambiaría las rutas, y 7 significado que usted cambiaría definitivamente.*

Hace definitivamente no						Hace definitivamente
1	2	3	4	5	6	7

6. Qué acontecimiento (o el problema) ocurría en este camino?
   Accidente Construcción otro _____

7. Fue este un mayor o secundario (el acontecimiento) el problema? Mayor menor

8. Cómo tiempo mucho más extra le hace espera que su viaje tome basado en la información que usted acaba de ver?

< 10 minutos 11-20 minutos 21-30 minutos 31-40 minutos Mas de 40 minutos

Apriete el espaciador para ver el próximo signo.

Graphic 5: Trabaje Texto de Zona Tiempo: _____segundos

Preguntas:

4. Qué acontecimiento (o el problema) ocurría en este camino?
   Accidente Construcción otro_____

5. Qué senda (sendas) puede usted manejar por esta área? Izquierdo Central Derecho

6. Dada la información que usted acaba de ver, que probable es que usted salga de la carretera y tome un sendero diferente a su destino? *Utilizar una escala donde 1 medios usted definitivamente no cambiaría las rutas, y 7 significado que usted cambiaría definitivamente.*

Hace definitivamente no						Hace definitivamente
1	2	3	4	5	6	7

Part 2: Tiempo Limitado

Para la imagen final nosotros cambiaremos el formato demostraba el gráfico. Esta vez, la imagen aparecerá para una cantidad limitada de tiempo. Permanecerá en la pantalla por unos pocos segundos y entonces apagará automáticamente (usted no necesita tocar ningún botón durante este proceso). Usted entonces será hecho preguntas acerca de la información en el mensaje. ¿Tiene usted alguna pregunta?

Empiece el Ejemplo del cambio de tiempo. Ningunas preguntas serán preguntadas el ejemplo siguiente.

Apriete el espaciador cuando usted está listo para empezar. Recuerde que usted no necesitará tocar el espaciador otra vez. La imagen apagará por sí mismo después de unos pocos segundos.

Text 4: 1 las sendas bloquearon, ningún tiempo de la demora

Preguntas:

4. Dada la información que usted acaba de ver, que probable es que usted salga de la carretera y tome un sendero diferente a su destino? *Utilizar una escala donde 1 medios usted definitivamente no cambiaría las rutas, y 7 significado que usted cambiaría definitivamente.*

Hace definitivamente no						Hace definitivamente
1	2	3	4	5	6	7

5. Qué senda (sendas) puede usted manejar por esta área? Izquierdo Central Derecho

6. Cómo tiempo mucho más extra le hace espera que su viaje tome basado en la información que usted acaba de ver?

< 10 minutos 11-20 minutos 21-30 minutos 31-40 minutos Mas de 40 minutos