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16. Abstract Project

This report provides the results of an extensive laboratory investigation of a total of 15 specific issues related to DMS operations statewide. These issues were identified and approved by TxDOT project advisors responsible for DMS operations in their respective districts. Laptop computers were used to simulate DMS message displays. After each message display, participating subject drivers responded to questions designed to determine the level of recall and comprehension of the information contained in the message. Response times as well as message format/sign operating preferences were also collected from the subject drivers.

The report contains specific recommendations concerning DMS issues in the following four categories:

1. communicating time and day for future roadwork to motorists,
2. motorist interpretations of specific words or phrases used on DMSs,
3. DMS operating practices, and
4. using DMSs with lane control signals.

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IMPROVED DYNAMIC MESSAGE SIGN MESSAGES AND OPERATIONS

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DISCLAIMER

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 views or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration. This report is not intended to constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. The engineer in charge of the study was Dr. Conrad L. Dudek, P.E. #24320.

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1. INTRODUCTION

Statement of the Problem

Dynamic message signs (DMS), also termed changeable message signs (CMS) and variable message signs (VMS), are a key component of the freeway traffic management systems that have been or are being installed by the Texas Department of Transportation (TxDOT) in several districts. To be effective, a DMS must communicate a meaningful message that can be read and comprehended by motorists within a very short time period (constrained by the sight distance characteristics of the location and design features of the DMS).

Since DMSs represent many motorists' primary concept of intelligent transportation systems (ITS), improperly designed or operated DMSs will have a negative impact on the public's perception of ITS in general. It is imperative, therefore, that the content, format, and application of information on the DMSs are of the highest possible quality and consistency statewide. Human factors and traffic operations research have been previously conducted to develop fundamental principles and guidelines for DMS message design *(1-15)*. These have proven to be very useful to practitioners. However, as more and more DMSs are implemented and operated, questions continue to arise concerning the best way to operate these devices. Without a solid research basis upon which to base answers to these new questions, DMS operators must rely on their own instincts and best judgement. This subjectivity then leads to inconsistencies from region to region that can confuse motorists who travel in multiple regions. The fact that DMSs are operated by different traffic management centers in different cities should be transparent to motorists as they travel from one region of the state to the other. In addition, some operator instincts as to the best messages to display and operating strategies to employ can actually be detrimental to proper motorist understanding and response to the DMS.

Background

DMSs can be an effective tool for communicating with motorists. However, displaying messages that are too long for motorists to read at prevailing highway speeds or that are too complex or inappropriately designed leading to motorist confusion, can adversely affect both traffic flow and the transportation agency's credibility. The messages displayed must be "transparent" to travelers in the state or region. Therefore, messages need to be presented in a consistent manner and order based on motorist's expectancies.

Uninformed transportation personnel sometimes display messages that are too long for motorists, particularly slower readers such as the elderly, to read while driving at prevailing speeds. Research has indicated that the reading times for DMSs are higher than for static guide signs. The distinguishing factor is that motorists can scan guide signs for relevant information; whereas, they must read the entire message displayed on DMSs in order to understand the message. Often, tradeoffs must be made as to what elements of the message should be omitted. There are many signing situations that require message design tradeoffs, which need to be addressed in advancing the state-of-the-art of message design.

In developing messages, factors that enhance understanding of messages include the following:

1. simplicity of words,
2. brevity,
3. standardized order of words,
4. standardized order of message lines, and
5. using understood abbreviations when abbreviations are needed.

Formatting Effective DMS Messages

Message formatting refers to constructing the DMS message so that it contains the proper information in the expected order to allow motorists to easily read and interpret the information and make rational decisions based on that information. Placement of message elements on the wrong line or in the wrong sequence will result in driver confusion and will increase message reading times. Conversely, consistent formatting of information enhances motorist expectations and will reduce the time required to read and understand messages (6).

The concepts of message load, message length, and message familiarity significantly affect message formatting requirements for a DMS. Message load refers to the number of informational "units" contained in a message. A unit of information refers to each separate data item given in a message that a driver could recall and could be used as a basis for making a decision. Answers are each one unit. The message in the following table has five (5) units of information and serves to illustrate the concept of units of information.

Table 1-1. Example of Information Units in a DMS Message.

INFORMATIONAL UNIT				
Question		**Answer**		**Info Unit**
1. What happened?	⇨	**ACCIDENT**	⇨	**1 unit**
2. Where?	⇨	**AT I-10**	⇨	**1 unit**
3. What effect on traffic?	⇨	**DELAY**	⇨	**1 unit**
4. Who is advisory for?	⇨	**GALVESTON**	⇨	**1 unit**
5. What is advised?	⇨	**USE LOOP 410 W**	⇨	**1 unit**

A unit of information typically is one to three words, but at times can be up to four words.

Message length is related to message load, but is not the same. Message length is the actual number of words or characters displayed. Two messages could contain the same amount of information (load) but have very different lengths, depending on the words and abbreviations used. This could also affect driver reading and comprehension time. Evidence suggests that at high vehicle operating speeds such as occurs on freeway facilities, eight-word messages of four to eight characters per word (excluding prepositions) may be approaching the limit of the

average motorist's processing capability. Messages longer than eight words may lead to message overload conditions, leading to operational problems such as traffic slowing down in the vicinity of a DMS *(2,6)*.

Message familiarity enhances motorist reading time. When information displayed on a DMS applies to unfamiliar motorists or when the information being presented to commuters is unusual, longer reading times will be required than information posted frequently and seen repeatedly by commuting traffic. Obviously, site-specific characteristics and normal DMS operating procedures dictate what information is usual and what is not, and so this factor varies from location to location.

A final key concept of DMS message design that significantly influences motorist reading and comprehension times is the division of a DMS message into multiple parts, or "frames," that are shown sequentially on a DMS. Dudek and Huchingson reported that no more than three units of information should be displayed on one frame or sequence when all three units must be recalled by motorists *(6)*. Also, no more than two units of information should be shown on a single line of the sign. Since motorists can process only a limited amount of information during the brief time they are exposed to the DMS, they recommend that a complete DMS message be limited to no more than four units of information, divided into two frames having two lines of information each *(6)*.

Properly applied, these concepts and principles form the foundation for effective DMS message design. It is critical to develop an effective, transparent DMS system that is both consistently perceived and interpreted by motorists as they travel from one part of the state to another. At the same time, this system must be able to adequately treat the unique information needs (both current and future) of each of the local areas in which DMSs are being operated. The key, then, is how well these principles are meshed to the needs and practices of motorists and the operating agency from both the statewide and the local level.

Objective of Study

The goal of this project was to help TxDOT improve the effectiveness and utilization of DMSs as key components in the advanced traffic management systems (ATMS) being deployed statewide. To accomplish this goal, TTI researchers focused on identifying, developing, and evaluating DMS messages and strategies in current or proposed use by traffic management centers statewide. The research involved extensive human factors laboratory studies to determine those messages and DMS operating strategies that best convey information required and desired by motorists.

Contents of This Report

This report contains the results of laboratory studies conducted in five cities in Texas (namely, Dallas, El Paso, Fort Worth, Houston, and San Antonio) designed to evaluate the effectiveness of selected DMS message terms, formatting options, and operating strategies. A number of specific questions of interest were identified through a review of national practices

and input from a TxDOT project advisory committee. Studies to evaluate each of these individual questions were then prepared. The overall experimental plan for these studies is described in Chapter 2. The results of each of the individual study are presented in Chapters 3 through 17. Conclusions and recommendations are presented in Chapter 18.

2. EXPERIMENTAL PLAN

Research Issues

During the first year of this project, a number of TxDOT DMS issues that could impact message effectiveness were reviewed and identified. Based on this review and knowledge of DMS operations in systems outside of Texas, candidate laboratory studies were submitted to the project advisory committee to review and prioritize. The committee selected a number of DMS issues for evaluation. These issues fell into one of four categories:

- communicating time and day for future roadwork to motorists,
- motorist interpretations of specific words or phrases used on DMSs,
- DMS operating practices, and
- using DMSs with lane control signals.

Specific research items under each category are described below.

Alternative Messages for Communicating Time and Day for Future Roadwork

TTI researchers evaluated several alternative messages that could be used to communicate a certain time or day when roadwork is to take place. The following three issues were examined:

- motorist understanding of calendar dates versus days of the week for communicating future roadwork activities;
- motorist interpretation of the term "FOR 1 WEEK" as a shorter alternative term to the use of days and times to communicate roadwork for seven days; and
- motorist interpretation of the term "WEEKEND" as a shorter alternative to communicate that roadwork begins on Friday evening and lasts until Monday morning.

Interpretation of Certain Words or Phrases

The second group of studies was directed at evaluating certain words or phrases for which actual motorists' understanding and interpretation were unknown. Five specific issues of interest in this category were as follows:

- motorist understanding of alternative travel time messages;
- motorist understanding of the terms "EXIT CLOSED" and "RAMP CLOSED" when referring to an exit ramp;
- motorist interpretation of a highway number or other route number without displaying the route prefix (I , US, SH, FM);
- motorist interpretation of the word "CONGESTION" and the descriptors "MAJOR," "HEAVY," MINOR," and "NORMAL"; and

- motorist understanding of the term “HIGH-PROFILE VEHICLES” used to warn motorists of high winds.

DMS Operation Practices

The efficacy of six DMS operating practices was also examined. These issues were as follows:

- effect of flashing an entire single-frame;
- effect of flashing one line of a one-frame message;
- effect of redundancy in a two-frame message: keeping two lines of a two-frame message the same and changing the last line on each frame;
- effect of three-frame messages versus two-frame messages on a portable DMSs;
- effect of cycling once through a two-frame message during the motorist’s available viewing time versus cycling twice; and
- effect of presenting four units of information simultaneously on one frame of a DMS versus splitting the information and displaying it on two frames.

Use of DMSs with Lane Control Signals

Finally, TTI researchers evaluated whether motorists can properly interpret information being presented by both DMS and lane control signals (LCS) in the driving environment. The specific issue examined in these studies was the following:

- motorists’ ability to combine and properly interpret information on DMS and LCS when lane closures are present.

Study Design

TTI researchers developed a rigorous experimental design to properly evaluate the above 15 issues. As a result of message counterbalancing needs, each subject driver in the study reviewed 42 messages. Because of the need to control the display times of some of the messages being evaluated and to measure the required reading times for other messages, TTI researchers developed interactive studies for the participating subject drivers using laptop computers.

Each issue evaluated was developed as an independent study within an overall laboratory session for each subject driver. In most cases, the issues were evaluated in terms of their effect upon motorist comprehension times, interpretation accuracy, and perceived importance of the message being displayed.

Laboratory Instrument

The laboratory instrument consisted of 42 messages for each subject to view, divided into five sections. To avoid the occurrence of primacy bias, the order of message displays was interchanged. There were two groups in each city; where Group 1 would view the messages in one order, and Group 2 would view the messages in the opposite order. Each subject driver viewed each message once in Section 1 and 2. In Sections 3, 4, and 5, subjects would view each message at least twice, and in some cases the messages were shown a third time to obtain the participant's message preference. The order in which the participants completed Sections 3, 4, and 5 was further interchanged to reduce learning or other biases.

Pilot Study

A preliminary laboratory instrument was developed and tested with eight individuals in the Bryan/College Station area. The purpose of the pilot study was to assess the administration procedures, determine the length of the time needed for each subject to complete the laboratory session, assess the format of the laboratory instrument, and identify any question deficiencies. The preliminary laboratory instrument and procedures were modified based on the results and participant's comments. The final laboratory instrument is provided in Appendix A.

Laboratory Instrument Administration

Study Locations

Studies were conducted in the following five cities: Dallas, El Paso, Fort Worth, Houston, and San Antonio. These cities currently operate DMSs. Studies were conducted in community centers, senior citizen centers, Department of Health sponsored GED classes, rented hotel rooms when necessary, and TTI research implementation offices located in Arlington, Dallas, Houston, and San Antonio.

Participant Recruitment

The laboratory instrument was administered to 260 individuals, 52 from each of the five study locations. Researchers made telephone contact with officials responsible for the potential study locations in each city. Upon official approval to conduct a study in a given location, public notices stating the requirements, compensation, and contact person and telephone number were forwarded to each agency for posting.

Because most of the messages evaluated would be for DMSs that would be used on freeways or highways, all subjects were required to have a current Texas driver's license, drive at least 8000 miles per year, and travel on a freeway or highway at least 12 times per year.

Demographics

A demographic sample of the Texas driving population based on age, gender, and education level was used as a guide for subject selection. Statistics regarding ages and gender were obtained from the Texas Department of Public Safety. According to these statistics, females comprise approximately 51 percent of the driving population. However, for this study the subjects were evenly divided by gender. Table 2-1 shows the demographic sample obtained based on cross-referencing the gender, age, and education level of the Texas population. The Texas driving population education level was obtained from the 1990 United States Census *(16)*.

Table 2-1. Demographic Sample of Participants.

Age Category	Education Level								Total (%)
	No High School Diploma		High School Diploma		Some College		College Degree		
	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	
<25	2	2	2	2	2	2	2	2	15
25-39	4	4	4	4	4	4	4	4	31
40-54	4	2	2	4	4	2	4	2	23
55-64	2	2	2	2	2	2	2	2	15
65+	2	2	2	2	2	2	2	2	15
Total	13	12	12	13	13	12	13	12	100

n=260

Laboratory Session Protocol

Although the laboratory sessions were conducted using laptop computers, it was not necessary for the participants to have any computer experience. The only capability required of the subject drivers was to press the space bar at certain points in the session. The computer screen displayed instructions and the stimulus messages. After reading the instructions and viewing a message, the subject wrote the answers to specific open-ended questions on the study form. Each time the subject pressed the space bar, the program would advance to the next message. Prior to four of the sections, the subject was shown a practice message to familiarize the subject with the procedures; the simplicity of the remaining sections made a practice message unnecessary. The session took approximately one and one-half hours to complete. The subjects were compensated financially for their participation. Laboratory sessions were administered one at a time to subjects. Overall, data collected occurred over a two-month period in early 2000.

3. CALENDAR DATES VERSUS DAYS OF THE WEEK FOR COMMUNICATING FUTURE ROADWORK ACTIVITIES

Study Description

Questions Being Investigated

Advance warning of roadwork or special event activities is currently being displayed on DMSs throughout the state. Oftentimes calendar dates are used (e.g., JAN 25 – JAN 28) to indicate when the roadwork or special event activity begins and/or ends. Dudek and Huchingson recommend presenting days of the week rather than days of the month *(6)*.

This study was designed to compare typical messages employing calendar dates frequently used by TxDOT districts with messages using days of the week. The objective of this study was to determine whether the use of days of the week are better understood than calendar dates in communicating future roadwork activities.

Messages Tested

Below are the two separate messages that were given to the subject drivers in each of the study cities. The calendar dates given in the message were changed to correspond to days during the week following the study.

Message with calendar dates

ROAD CLOSED
[JAN 25 – JAN 28]

or

Message with days of the week

ROAD CLOSED
TUES – FRI

Study Protocol

Subjects were shown each type of message, one at a time. The order of the messages was counterbalanced. As such, one group was shown the message with the calendar dates first, while the other group saw the message with the days of the week first. The two messages were not

shown consecutively, but were displayed at different points in the overall laboratory session. Subjects viewed the sample sign message on the computer screen. They were then asked to list the days they thought the road would be closed.

Study Results

The results indicate that the subject drivers had difficulty in relating calendar dates to specific days of the week. However, a majority of the drivers were able to correctly identify the days the roadwork would take place when the days of the week were displayed.

Tables 3-1 and 3-2 present the results for the first message (calendar dates) and the second message (days of the week), respectively. For the message with calendar dates, Table 3-1 shows that only 21 percent of the subject drivers were able to give the correct days of the week. Also, there were a significant number of the subject drivers (47 percent) that did not know what days were implied by the dates shown. The many other responses provided also indicated that the subject drivers were unsure on which days the closure took place.

For the second message with the days of the week displayed, Table 3-2 shows that 85 percent of the subject drivers responded correctly as to when the closure would take place. In contrast to the message with calendar dates, only 2 percent of the subject drivers did not know which days the road would be closed.

The study results by city (Dallas, El Paso, Fort Worth, Houston, and San Antonio) are shown in Tables B-1 and B-2 in Appendix B.

Table 3-1. Responses to the Question "During Which Days of the Week Do You Think the Road Will Be Closed?" (Calendar Dates)

Calendar Date Responses	%
✔Gave correct days of the week	21
Mon., Tues., Wed., Thurs.	9
April 18, 19, 20, 21	4
Other Responses *(17 different groups of responses)**	19
Did not know	47

n=260

*None of the individual groups exceeded 3 percent.

Table 3-2. Responses to the Question "During Which Days of the Week Do You Think the Road Will Be Closed?" (Days of the Week)

Days of the Week Responses	%
✔Gave correct days of the week	85
Tues. & Fri.	5
Other Responses *(11 different groups of responses)**	8
Did not know	2

n=260

*None of the individual groups exceeded 2 percent.

Recommendations

The results of this study illustrated that drivers have difficulties in corresponding calendar dates (e.g., JAN 25 – JAN 28) with specific days of the week. Thus, the use of days of the week is preferred over calendar dates. It is recommended that days of the week (e.g., TUES – FRI) should be used when the message is displayed for a work activity that will occur within the upcoming week.

4. USE OF THE TERM "FOR 1 WEEK" FOR ROADWORK LASTING SEVEN DAYS

Study Description

Questions Being Investigated

Frequently, TxDOT performs roadwork over a one-week period (i.e. Thursday – Wednesday). If the term "1 WEEK" has a specific meaning, then it would take less DMS space to display than using the corresponding days of the week. This study was designed to determine whether motorists interpret the term "FOR 1 WEEK" the same as a Thursday through Wednesday (including Saturday and Sunday) when they view the message on a Thursday.

Messages Tested

Since the term "1 WEEK" is ambiguous and could mean starting in one week or lasting one week, the preposition "FOR" was used to provide this distinction. Subjects in all five cities viewed the sample sign message below:

ROADWORK
FOR 1 WEEK

Study Protocol

Subjects were instructed to assume they saw the message on a Thursday morning. They were then asked to list all the days of the week they thought roadwork would take place.

Study Results

As shown in Table 4-1, the participants had a wide variety of interpretations for the term "FOR 1 WEEK." This could be attributed to the subject drivers' uncertainty as to whether the roadwork begins on the date of viewing, the next day, or from the beginning of the current or next work week. While 76 percent of the subjects included Saturday and Sunday in their response, it is apparent that there is no consensus of which weekdays are included in the term "FOR 1 WEEK." Only 28 percent of the drivers interpreted the message to mean Thursday through Wednesday including Saturday and Sunday, while an additional 21 percent included the following Thursday. Eight percent indicated the work would begin on the next Monday and continue through Friday. The study results by city are show in Table B-3 in Appendix B.

Table 4-1. Responses to the Question "List the days you think there will be roadwork."

Responses	%
Responses that did include Saturday and Sunday	
Thurs., Fri., Sat., Sun., Mon., Tues., Wed.	28
Thurs., Fri., Sat., Sun., Mon., Tues., Wed., Thurs.	21
Fri., Sat., Sun., Mon., Tues., Wed., Thurs.	10
Other Responses *(14 different groups of responses)**	16
Total responses that did include Saturday and Sunday	76
Responses that did not include Saturday and Sunday	
Thurs., Fri., Mon., Tues., Wed.	3
Mon., Tues., Wed., Thurs., Fri.	8
Other Responses *(12 different groups of responses)**	11
Did not know	2
Total responses that did not include Saturday and Sunday	24

n=260

*None of the individual groups exceeded 4 percent**.**

Recommendations

The results of this study indicate that the drivers had difficulty identifying which days to include for the term "FOR 1 WEEK." The term "FOR 1 WEEK" was found to be ambiguous as to whether the roadwork begins the date the message is viewed, the next day, or from the beginning of the current or next work week. It is recommended that the days of the week (e.g., THURS THRU WED) be used in place of the term "FOR 1 WEEK." This result does imply that the message must be changed daily to maintain accuracy.

5. USE OF THE SHORTER TERM "WEEKEND" TO DESCRIBE ROADWORK THAT BEGINS ON FRIDAY EVENING AND LASTS UNTIL MONDAY MORNING

Study Description

Questions Being Investigated

Oftentimes, major lane or roadway closures are necessary on the weekend, with activities beginning on Friday evening and lasting till early Monday morning. Due to the limitation of space on many portable DMSs, it is desirable to use a shorter phrase, such as "WEEKEND" when possible. It is not known if drivers understand that roadwork on the weekend includes Friday evening and Monday morning or just Saturday and Sunday. In addition, it is important to know whether this descriptor has specific time connotations (i.e., approximate beginning and end hours). The objective of this study was to determine if "WEEKEND" may be used in place of a more lengthy message such as "7PM FRI TO 5AM MON."

Messages Tested

To determine drivers' interpretation of the term "WEEKEND" the following sample sign was displayed to each participant:

ROADWORK
NEXT
WEEKEND

Study Protocol

Prior to displaying the message, the subjects were told to assume they were driving on an interstate highway. They were then shown the message and asked what information the sign gave them about the days and hours the roadwork would occur.

After presentation of the message, drivers were asked the following four questions:

1. Do you think "WEEKEND" means work begins Friday evening or Saturday morning?
2. At approximately what hour does it begin?
3. Do you think "WEEKEND" means work ends Sunday evening or Monday morning?
4. At approximately what hour does it end?

To avoid the occurrence of primacy bias, the order of terms Friday evening and Saturday morning were interchanged as to which appeared first in the question. For example, on half of the forms the term Friday evening was placed first and on the other half the term Saturday

morning was first. This format was also used for the terms Sunday evening and Monday morning. In addition, the participants were asked to identify the approximate beginning and end hours of the roadwork on the days they selected.

Study Results

Driver Interpretation Of What Day And Time "WEEKEND" Work Will Begin

A summary of the drivers' responses to the day that the work begins is shown in Table 5-1. When asked if the work begins on Friday evening or Saturday morning, the drivers' responses were divided. Of the drivers surveyed, 62 percent stated that work begins on Saturday morning. The remaining participants (38 percent) selected Friday evening.

Table 5-1. Responses to the Question "Do You Think 'WEEKEND' Means Work Begins Friday Evening or Saturday Morning?"

Day Roadwork Begins	%
Friday evening	38
Saturday morning	62
No response	0

n=260

Specific starting times for a weekend are summarized in Table 5-2. Forty-nine percent of the subject drivers selected Saturday morning at 5, 6, 7, or 8 AM as the starting time for the work. Only 23 percent indicated Friday evening between 5 PM and 9 PM as the start time. A total of 12 percent of the subject drivers selected 12 midnight between Friday and Saturday as the starting time for the roadwork, and 58 percent selected a time after 5 AM on Saturday morning.

Driver Interpretation Of What Day And Time "WEEKEND" Work Will End

A summary of the drivers' responses to the day that weekend ends is shown in Table 5-3. Sunday morning was selected by 69 percent of the drivers surveyed; while Monday morning was selected by 30 percent.

The ending times for the work are summarized in Table 5-4. Forty-eight percent of the subject drivers selected Sunday evening between 5 PM and 10 PM as the ending time for the work, with an additional 20 percent selecting 12 midnight between Sunday and Monday. Sixteen percent chose Monday morning (5, 6, or 9 AM) as the ending time.

The study results by city are shown in Tables B-4 through B-7 in Appendix B.

Table 5-2. Responses to the Question "At Approximately What Hour Does It Begin?"

Time Roadwork Begins	%
Friday, 5 PM	4
Friday, 6 PM	8
Friday, 7 PM	4
Friday, 8 PM	4
Friday, 9 PM	3
Friday, 12 AM Midnight	12
Saturday, 5 AM	4
Saturday, 6 AM	15
Saturday, 7 AM	18
Saturday, 8 AM	12
Other Responses *(12 different groups of responses*)	13
No response	3

n=260

*None of the individual groups exceeded 4 percent.

Table 5-3. Responses to the Question "Do You Think 'WEEKEND' Means Work Ends Sunday Evening or Monday Morning?"

Roadwork Ends	%
Sunday evening	69
Monday morning	30
No response	1

n=260

Table 5-4. Responses to the Question "At Approximately What Hour Does It End?"

Time Roadwork Ends	%
Sunday, 5 PM	15
Sunday, 6 PM	16
Sunday, 7 PM	7
Sunday, 8 PM	4
Sunday, 10 PM	6
Sunday, 12 AM Midnight	20
Monday, 5 AM	8
Monday, 6 AM	5
Monday, 8 AM	3
Other Responses *(12 different groups of responses*)	14
No response	2

n=260

*None of the individual groups exceeded 3 percent.

Recommendations

The results indicate that most drivers felt that the term “WEEKEND” meant the work would start on Saturday morning and end on Sunday evening. Therefore, it is not recommended to use the message term “WEEKEND” if the work is to start on Friday evening and end on Monday morning. In those cases, it would be helpful to indicate the day and hour. However, the message term “WEEKEND” may be used if the work is to start on Saturday morning from approximately 5:00 AM on and end by Sunday evening at midnight.

6. MOTORIST UNDERSTANDING OF TWO ALTERNATIVE TRAVEL TIME MESSAGES

Study Description

Questions Being Investigated

Some TxDOT districts display travel time information on DMSs during the peak periods in the absence of incidents. The travel times are after-the-fact (historic) because the capability does not exist to accurately predict travel times. The issue is whether motorists understand that the travel time information is not a predicted amount, but reflects the latest measurements of vehicles that have already traversed a given stretch of freeway and may not reflect the expected travel time for their specific trip segments. Travel times are easily measured by motorists, and if they believe the DMS information reflects the predicted travel times for their specific trip segments, credibility can be easily lost. The objective of this study was to determine motorist understanding of two formats for displaying travel time information on DMSs.

Messages Tested

To determine motorist understanding of the two alternative messages for displaying travel time information, subjects were shown the messages below:

TRAVEL TIME
TO DOWNTOWN
20 MINUTES

or

TRAVEL TIME
TO DOWNTOWN
AT 7:20 A.M.
20 MINUTES

Study Protocol

Subjects at each study location were divided into two groups. While subject drivers were shown both messages, one group would see the message without the time-of-day displayed first and the message with the time-of-day displayed second. The other group would see the

messages in the opposite order within the larger study. The subjects were told to assume they were traveling on an interstate highway toward downtown at 7:30 in the morning during the peak period. The following questions were then asked to identify motorists' understanding of the messages to reflect historical travel times (travel times of vehicles that have already traversed the route segment downstream of the motorist seeing the message) rather than a predicted travel time.

1. If you saw this message, what would it mean to you? Remember, you are traveling on interstate highway toward downtown **at 7:30 in the morning during the peak period**.

2. To me this means I can travel from my current location on the freeway to the downtown exit ramp in (check **one** of the following):
   ____ less than 20 minutes
   ____ exactly 20 minutes
   ____ about 20 minutes
   ____ more than 20 minutes
   ____ I am unable to determine based on the information given on the sign

Study Results

Table 6-1 summarizes the responses obtained when drivers were asked what the message meant to them. The responses indicate that the majority of drivers (approximately 80 percent) perceived the messages to mean that it would take 20 minutes to downtown. No significant difference existed between the two message formats (with or without the time-of-day displayed).

Table 6-1. Response to the Question "If You Saw This Message, What Would It Mean To You?"

Responses	Message without time-of-day shown (%)	Message with time-of-day shown (%)
20 minutes to downtown	80	78
Other	18[a]	17[b]
Did not know	2	5

n=260

[a] 16 different groups of responses (none of the individual groups exceeded 6 percent)

[b] 17 different groups of responses (none of the individual groups exceeded 6 percent)

Table 6-2 provides a summary of responses for the second question. The results show that 76 percent of the participants who viewed the message without the time-of-day shown selected "about 20 minutes," in contrast to 64 percent who selected that response without the time-of-day shown. The results also show no difference between presentation formats in the percent of subject drivers who selected "exactly 20 minutes." Rather, the difference between presentation formats appears to be due to more subject drivers selecting "less than 20 minutes"

and “more than 20 minutes” when the time-of-day information is included in the message. What is even more significant is that only about 10 percent of the subject drivers believed that it would take them exactly 20 minutes to reach downtown regardless of which of the two alternative messages is displayed. Therefore, about 90 percent understand the time as an approximate. TTI researchers hypothesize that with the time-of-day information provided, some subject drivers attempt to use their local knowledge of congestion patterns during the peak period and thus try themselves to predict current travel times based on what they know to be the most recent historical travel time.

The study results by city are shown in Tables B-8 and B-9 in Appendix B.

Table 6-2. Response to the Question “To Me This Means I Can Travel from My Current Location on the Freeway to the Downtown Exit Ramp In:”

Responses	Message without time-of-day shown (%)	Message with time-of-day shown (%)
Less than 20 minutes	2	7
Exactly 20 minutes	11	10
About 20 minutes	76	64*
More than 20 minutes	9	13
Unable to determine	2	6
Did not respond	0	0

n=260

*Significantly different (Z=2.11) than the “without time-of-day” message (α=0.05)

Recommendations

The results of the study indicate that only about 10 percent of the subject drivers interpreted the message to mean that it would take exactly 20 minutes to travel from the DMS to the destination posted regardless of whether time of day was placed in the message. However, displaying the time-of-day may help some motorists use their local knowledge to predict a current travel time based on when that most recent travel time information was gathered. Although not measured directly in this study, it is believed that this ability yields the DMS operating agency (i.e., TxDOT) more credibility with the driving public. Therefore, TTI researchers recommend displaying the time-of-day on travel time messages when possible.

7. USE OF THE TERMS "EXIT CLOSED" AND "RAMP CLOSED" WHEN REFERRING TO AN EXIT RAMP

Study Description

Questions Being Investigated

Throughout Texas, TxDOT is currently using the terms "exit" and "ramp" interchangeably on DMSs. However, there is no indication if drivers interpret the terms having the same meaning or different meanings. The term that is most understood by the drivers should be standardized throughout Texas.

Messages Tested

To determine if the expressions "EXIT CLOSED" and "RAMP CLOSED" are equivalent or if there is a difference in their meaning, TTI researchers conducted an experiment where subject drivers in each of the study cities viewed the following two messages.

EXIT CLOSED	RAMP CLOSED

Study Protocol

Subjects were shown both message terms simultaneously. To avoid bias, the order that the two terms were displayed was counterbalanced among participants. The subjects were reminded that they were still traveling on a freeway in their perspective city and then asked to answer the following three questions:

1. Do these two messages mean the same thing? Yes___ No___.
2. If your answer to Number 1 is "no," briefly explain the difference.
3. What do the messages mean in terms of your driving plans?

Study Results

Table 7-1 shows that 59 percent of the drivers interpret the terms "EXIT and "RAMP" to have the same meaning. In contrast, 41 percent stated that the terms had different meanings. The interpretations of the two terms by the latter group are given in Tables 7-2 and 7-3. Of the drivers who had indicated that the two terms had a different meaning, 67 percent felt an exit is used to leave a highway or freeway. In contrast, 45 percent thought a ramp is used to enter a highway or freeway. There were no drivers that felt the term "ramp" meant an exit off a

highway or freeway. In addition, 8 percent of the drivers indicated that a ramp is used as a freeway to freeway connector.

Table 7-1. Responses to the Question "Do These Two Messages Mean the Same To You?"

Response	%
Yes	59
No	41

n=260

Table 7-2. Driver Definition of an Exit.

Responses	%
Exit is used to get off a highway/freeway	67
Other Responses *(13 different groups of responses)**	28
Did not know	1
Did not respond	4

n=107

*None of the individual groups exceeded 2%.

Table 7-3. Driver Definition of a Ramp.

Responses for definition of an Ramp	%
Ramp is used to get on a highway/freeway	45
Freeway to freeway connector	8
Other responses *(20 different groups of responses)**	43
Did not know	1
Did not respond	3

n=107

*None of the individual groups exceeded 4%.

The third question asked the subjects what impact the messages would have on their driving plans. As shown in Table 7-4, 80 percent of the group responded with an appropriate answer, such as go to the next available ramp, use an alternate route, or could not exit. In addition, 2 percent stated that they could not get off the freeway.

The study results by city are shown in Tables B-10 through B-13 in Appendix B.

Table 7-4. Responses to the Question "What Does This Message Mean in Terms of Your Driving Plans?"

Responses	%
Go to next exit/ramp, Use alternate route, Continue on highway or freeway	80
Can not get off or on freeway	2
Other responses *(25 different groups of responses)**	13
Did not know	3
Did not respond	2

n=107

*None of the individual groups exceed 2%.

Recommendations

Subject drivers most commonly associated the term "EXIT" with ramps leaving the freeway/highway. Conversely, subject drivers were not in agreement with respect to their interpretation of the term "RAMP," although 45 percent indicated that a "RAMP" is used to get on the freeway/highway. TTI researchers recommend using the word "EXIT" when referring to an exit ramp on a freeway. The term "RAMP" should not be used when referring to an exit ramp.

8. OMITTING THE ROUTE DESIGNATION FROM A MESSAGE

Study Description

Questions Being Investigated

Due to constraints in line length on portable DMSs, TxDOT may occasionally find it necessary to omit the route designation (prefix of a route), such as "I, US, or FM," in the context of a message when it refers to an interstate highway number or other route number. The issue in this study was whether this exclusion of the route prefix is confusing to local motorists.

Message Tested

To evaluate the interpretation of using a highway number or other route number without using the route prefix, subject drivers in the five study cities viewed the sign message below:

EXIT
TO [*HIGHWAY #*]
CLOSED

The message for each city was changed so that the highway or route numbers in the message referred to a heavily traveled interstate or highway in that city.

Study Protocol

Subject drivers were shown the study message and asked if they saw this message while traveling on a particular interstate highway (e.g., 35, 45), what would they think the number meant?

Study Results

Table 8-1 contains the results of this study. Only 75 percent of the subjects correctly identified the number displayed on the message as an interstate or another highway. Additionally, 17 percent of the subject drivers felt that the message number was referring to a particular exit number. Only 2 percent stated that they did not know to what the number referred. The remaining 6 percent gave a number of different responses, including mile marker, distance to the exit, and speed limit.

The study results by city are shown in Table B-14 in Appendix B.

Table 8-1. Responses to the Question "What Does the Number In the Message Refer To?"

Responses	%
Another Highway, Route, or Interstate	75
Exit Number	17
Other Responses *(10 different groups of responses)**	6
Did not know	2

n=260

*None of the individual groups exceeded 2 percent.

Recommendations

Since the comprehension of the highway number was below a commonly accepted 85 percent threshold level, it is recommended that the highway or route numbers be displayed with the route or interstate designation when used on a DMS. The number used alone may be confusing to local drivers and possibly to drivers from other states.

9. MOTORIST INTERPRETATION OF THE WORD "CONGESTION" AND ITS DESCRIPTORS "MAJOR," "HEAVY," "MINOR," AND "NORMAL"

Study Description

Questions Being Investigated

Many TxDOT DMS messages being used in the various districts indicate the presence of congestion on the roadways. These messages are not always being presented consistently or necessarily intended to reflect similar operating conditions from district to district. Furthermore, there is interest by some of the districts to apply descriptors to the "CONGESTION" term to further distinguish between various operating conditions on the roadway. This inconsistency in intent and application can create confusion for motorists who regularly or occasionally travel in more than one city in the state.

In this study, TTI researchers searched for the answers to two key questions:

- What is the expectation of motorists when they see a message containing the word "CONGESTION?"
- How do the descriptors "MAJOR," "HEAVY," "MINOR," and "NORMAL" affect motorist perception of the term "CONGESTION?"

Messages Tested

To evaluate these questions, TTI researchers showed subject drivers the following five messages one at a time:

- CONGESTION,
- NORMAL CONGESTION,
- MINOR CONGESTION,
- HEAVY CONGESTION, and
- MAJOR CONGESTION.

Study Protocol

TTI researchers changed the presentation order of the above terms among the subject drivers as much as practical in order to avoid primacy bias. For each message, subject drivers were asked their opinion regarding three potential measures of traffic conditions. Subject drivers were instructed to envision themselves traveling on a major freeway towards the downtown area of their city during the morning peak period. The questions and potential responses allowed are shown below.

1. To me, this (message) means that I will experience a delay of (check **one** of the following):
   ____ up to 5 minutes
   ____ 5 minutes or more
   ____ 10 minutes or more
   ____ 15 minutes or more
   ____ 20 minutes or more
   ____ 30 minutes or more
   ____ 1 hour or more
   ____ 2 hours or more

2. To me, this (message) means that the speed at which I will be able to drive will be (check **one** of the following):
   ____ 55 miles per hour and above
   ____ between 45 and 55 miles per hour
   ____ between 35 and 45 miles per hour
   ____ between 25 and 35 miles per hour
   ____ between 15 and 25 miles per hour
   ____ less than 15 miles per hour

3. To me, this (message) means that I will have to drive at the above selected speed for (check **one** of the following):
   ____ less than 1 mile
   ____ 1 to 2 miles
   ____ 2 to 3 miles
   ____ 3 to 4 miles
   ____ more than 4 miles

After answering these questions for all of the message alternatives, subject drivers were then asked to compare the relative severity of congestion among the terms.

Although previous research has shown that drivers are very interested in the delay impacts of congestion, current traffic surveillance systems typically measure the effects of congestion in terms of reduced speeds and limits of congestion. The primary exception to this is the automatic vehicle identification system in Houston that measures link travel times directly. Consequently, it is useful to determine whether drivers have a clear expectation of the effects of congestion in terms of those direct measurements.

Study Results

Effect of Messages on Expectations of Delay

The distributions of subject driver perceptions of delay implied by the alternative messages are summarized in Table 9-1. A general trend is evident between "CONGESTION," "NORMAL CONGESTION," and "MINOR CONGESTION" at the lower levels of perceived

delay, and between "MAJOR CONGESTION" and "HEAVY CONGESTION" at higher levels of perceived delay. Statistically, no significant differences were detected in the average amount of delay implied by "CONGESTION," "NORMAL CONGESTION," and "MINOR CONGESTION" messages (as depicted by the vertical line adjacent to the rows that are not significantly different). Generally speaking, these messages implied an average delay to subject drivers of about 15 minutes and implied a delay of between 18 and 24 minutes to the 85th-percentile subject driver. Conversely, the average delay implied by "MAJOR CONGESTION" and "HEAVY CONGESTION" were both significantly higher than for the other three congestion messages. Furthermore, the averages were significantly different from each other. The message "MAJOR CONGESTION" implied an average delay of over 45 minutes to subject drivers, whereas the message HEAVY CONGESTION implied an average delay of slightly less than 40 minutes. For the 85th-percentile subject driver, "HEAVY CONGESTION" implied a delay of 51 minutes or greater, whereas "MAJOR CONGESTION" implied a delay of 60 minutes or more.

Table 9-1. Amount of Delay Implied by Messages.

Message	5 min or more (%)	10 min or more (%)	15 min or more (%)	20 min or more (%)	30 min or more (%)	60 min or more (%)	120 min or more (%)	Ave Delay Implied (min)	85th %-tile Delay Implied (min)
Normal Congestion	36	24	18	10	8	4	1	14.5	18
Minor Congestion	32	22	21	10	10	2	3	16.5	20
Congestion	19	24	18	18	17	3	1	17.5	24
Heavy Congestion	5	5	13	14	33	21	9	38.7	51
Major Congestion	1	2	8	17	28	33	11	46.3	60

A vertical line indicates that the values are not significantly different from each other.

The similarities and differences among the alternative congestion messages can also be seen quite clearly if the results in Table 9-1 are shown graphically as a cumulative distribution for each message. Using the delay levels shown in Table 9-1 as the lower limit at which each subject driver considers the congestion message to first be relevant, the cumulative distribution of each of the alternative congestion message is presented in Figure 9-1. As stated above, three of the messages (CONGESTION, NORMAL CONGESTION, and MINOR CONGESTION) generated very consistent cumulative distributions. Meanwhile, the curves for HEAVY CONGESTION and MAJOR CONGESTION fall considerably to the right. As the figure illustrates, approximately one-half of the subject drivers believed that the CONGESTION, NORMAL CONGESTION, and MINOR CONGESTION messages implied delays of 10 minutes or less. In contrast, approximately 50 percent of the subject drivers perceived HEAVY CONGESTION as implying a delay of at least 25 minutes, and MAJOR CONGESTION as implying a delay of about 30 minutes or more.

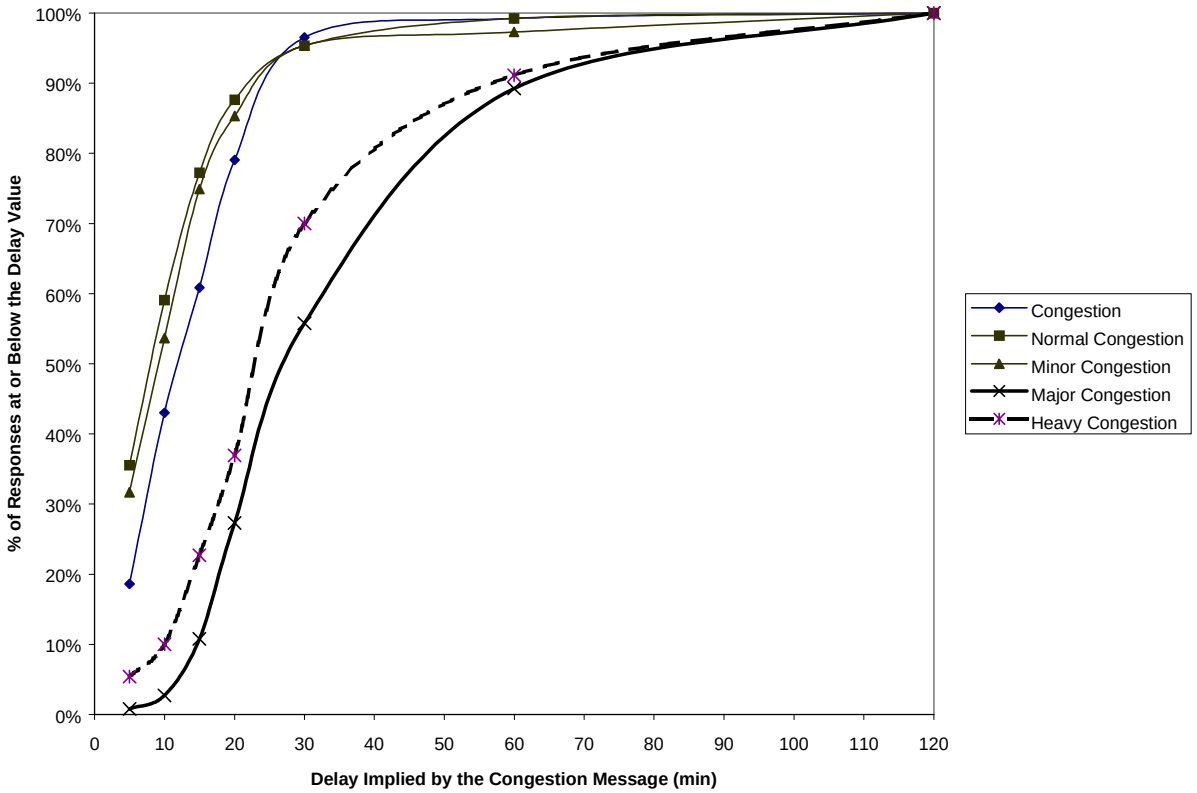

Figure 9-1. Amount of Delay Implied by Congestion Messages.

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Effect of Messages on Expectations of Speeds

The distributions of subject driver perceptions of expected downstream speeds implied by each of the alternative messages are summarized in Table 9-2. A general trend is again evident between "CONGESTION," "NORMAL CONGESTION," and "MINOR CONGESTION," and between "MAJOR CONGESTION" and "HEAVY CONGESTION." Statistically, no significant differences were detected in the average amount of delay implied by "CONGESTION" and "MINOR CONGESTION" messages ($\alpha = 0.05$), or between "MINOR CONGESTION" and "NORMAL CONGESTION." Generally speaking, these messages implied an expected speed downstream of between 35 and 40 mph. Conversely, expected downstream speeds implied by "MAJOR CONGESTION" and "HEAVY CONGESTION" were both significantly lower than for the other three congestion messages. Furthermore, the averages were significantly different from each other. The message "MAJOR CONGESTION" implied an expected downstream speed of less than 20 mph, whereas the message "HEAVY CONGESTION" implied an average expected downstream speed of about 23 mph.

Examination of the data with respect to the 85th-percentile subject driver further illustrates the lack of a strong distinction among the various congestion messages. Note that the 85th-percentile subject driver expects a downstream speed of between 51 and 55 mph when presented the terms "CONGESTION," "MINOR CONGESTION," OR "NORMAL CONGESTION." Conversely,

the terms “HEAVY CONGESTION” and “MAJOR CONGESTION” imply speeds of 36 and 41 mph, respectively, to the 85th-percentile subject driver.

Table 9-2. Expected Downstream Speeds Implied by Messages.

Message	Less than 15 mph (%)	15 – 25 mph (%)	25 – 35 mph (%)	35 – 45 mph (%)	45 – 55 mph (%)	55 mph and above (%)	Ave Speed Implied (mph)	85th %-tile Speed Implied (mph)
Congestion	11	21	16	22	21	9	34.8	52
Minor Congestion	6	16	22	19	29	8	37.4	51
Normal Congestion	5	14	15	22	26	18	40.7	55
Major Congestion	50	21	13	12	4	0	18.7	36
Heavy Congestion	33	27	17	15	8	0	23.0	41

A vertical line indicates that the values are not significantly different from each other.

The cumulative distributions of expected downstream speeds for the alternative congestion messages are presented in Figure 9-2. As implied by the average values in Table 10-2, three of the messages (”CONGESTION,” “MINOR CONGESTION,” and “NORMAL CONGESTION”) generated fairly consistent cumulative distributions. Perhaps more importantly, however, the gradual upward slope of these curves illustrates the wide range of interpretations of the congestion messages with respect to speed. Conversely, the curves for both “HEAVY CONGESTION” and “MAJOR CONGESTION” are shifted significantly to the left of the other curves and have a much sharper slope. The sharper slopes signify greater agreement among the subject drivers as to the speeds expected downstream. Based on these data, TTI researchers believe that “HEAVY CONGESTION” could be used to imply downstream travel speeds that are below 25 mph, and “MAJOR CONGESTION” could be used for average speeds that are 20 mph or below. These values would be consistent with the interpretation of at least 50 percent of the driving population in Texas. On the other hand, the messages “CONGESTION,” “MINOR CONGESTION,” and “NORMAL CONGESTION” do not seem to imply as consistent a meaning to motorists with respect to speed. If TxDOT chooses to display one of these types of messages, it should be limited to traffic conditions with a speed range that is below free-flow speed but greater than approximately 45 mph.

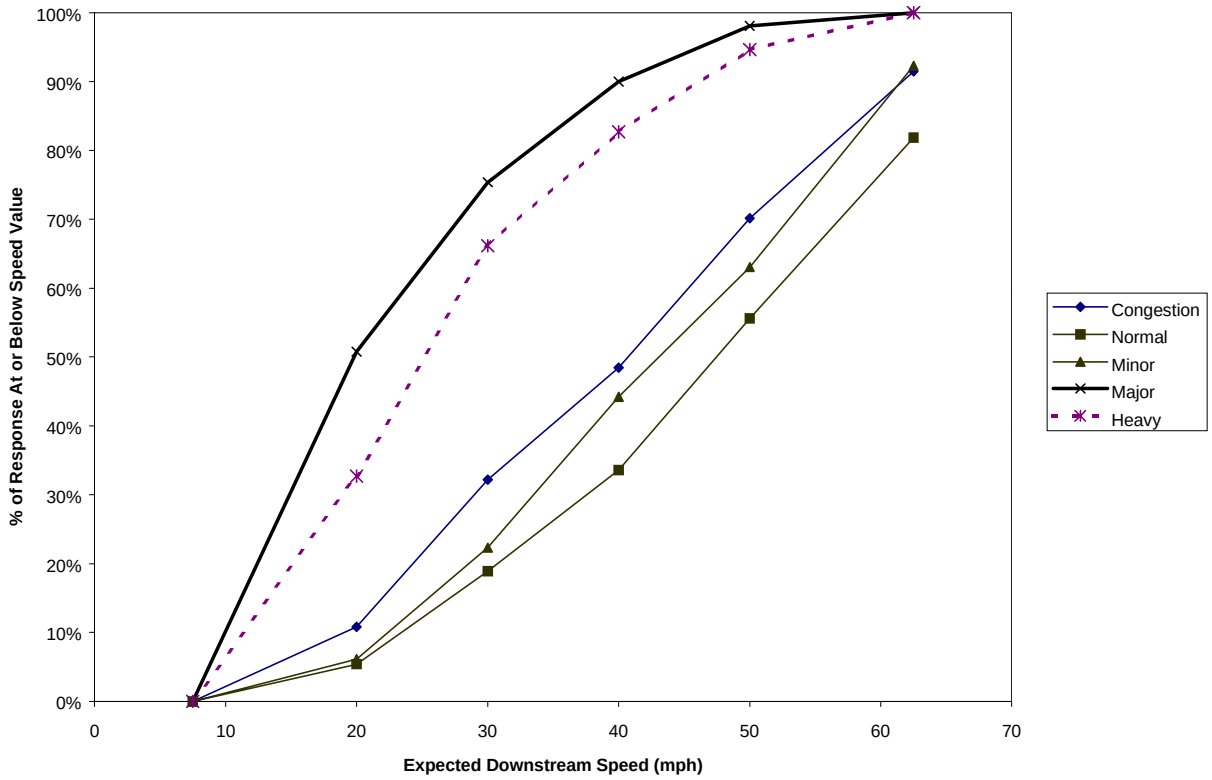


Figure 9-2. Downstream Travel Speeds Implied by Congestion Messages.

Effect of Messages on Expected Lengths of Congestion

The distributions of subject driver responses to the alternative congestion messages in terms of length of congestion to be encountered are presented in Table 9-3. As with the expectations of both delay and speed, the responses for length of congestion resulted in a division of the messages into two main groups. "CONGESTION," "NORMAL CONGESTION," and "MINOR CONGESTION" all yielded average expected lengths of congestion of about 2 miles, whereas "HEAVY CONGESTION" and "MAJOR CONGESTION" yielded average expected lengths of congestion of more than 3 miles. No significant differences were detected between messages within each of the two groupings, as depicted in Table 9-3. It is important to note, however, that there is essentially little distinction between any of the congestion messages when the 85th-percentile subject driver is considered. All of the messages resulted in expected lengths of congestion of 3 miles or more by the 85th percentile subject driver. This illustrates the difficulty subject drivers had in interpreting these messages in terms of this particular parameter.

Table 9-3. Expected Lengths of Congestion Implied by Messages.

Message	Less than 1 mile (%)	1 – 2 miles (%)	2 – 3 miles (%)	3 – 4 miles (%)	More than 4 miles (%)	Ave Length Implied (miles)	85th %-tile Length Implied (miles)
Minor Congestion	26	32	20	13	9	2.0	3
Normal Congestion	29	29	12	14	16	2.2	4
Congestion	20	30	25	11	14	2.3	4
Heavy Congestion	8	17	20	24	31	3.2	>4
Major Congestion	10	15	14	23	39	3.4	>4

A vertical line indicates that the values are not significantly different from each other.

Figure 9-3 provides a graphical representation of cumulative subject responses for each message. Once again, the curves for the "CONGESTION," "NORMAL CONGESTION," and "MINOR CONGESTION" responses have very gradual slopes, indicating less agreement among the subject drivers as to what lengths of congestion are actually implied by the message. Similar trend slopes are also evident for the "MAJOR CONGESTION" and "HEAVY CONGESTION" message. As suggested by the average congestion lengths shown in Table 10-3, it does appear that at least 50 percent of the subject drivers believe the terms "CONGESTION," "NORMAL CONGESTION," and "MINOR CONGESTION" imply 2 miles of congestion or less. Conversely, at least 50 percent of subject drivers expect 3 miles of congestion or more if they see either "HEAVY CONGESTION" or "MAJOR CONGESTION" displayed on a DMS. It becomes more difficult to distinguish among the various curves at the 85th-percentile subject driver level, however.

Relative Rankings of Congestion Messages

As part of the comparison of congestion messages, TTI researchers asked subject drivers to simply determine if one message implied conditions that were the same as, less severe, or more severe than, another congestion message. The following paragraphs summarize how responses were distributed:

- "CONGESTION" versus "NORMAL CONGESTION"

  37% CONGESTION is the same as NORMAL CONGESTION
  20% CONGESTION is less severe than NORMAL CONGESTION
  43% CONGESTION is more severe than NORMAL CONGESTION

As is implied by the estimates of delay, speed, and length of congestion in the previous sections, subject drivers were fairly evenly split as to whether they felt that a "CONGESTION" message implied a condition that was the same as, less severe, or more severe than "NORMAL CONGESTION." The implication of these results is that "NORMAL CONGESTION" cannot be used to indicate a different level of congestion than the term "CONGESTION."

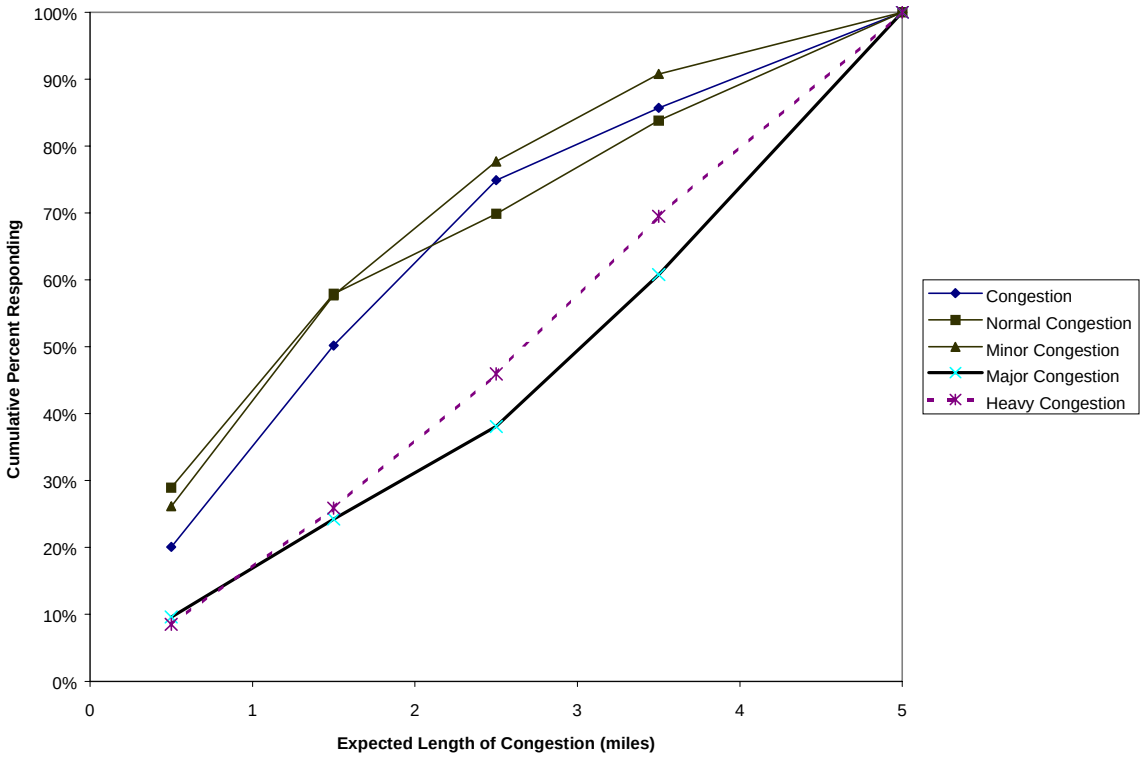


Figure 9-3. Length of Congestion Implied by Congestion Messages.

- "MINOR CONGESTION" versus "NORMAL CONGESTION"

  19% MINOR CONGESTION is the same as NORMAL CONGESTION
  43% MINOR CONGESTION is less severe than NORMAL CONGESTION
  38% MINOR CONGESTION is more severe than NORMAL CONGESTION

No clear differences are evident for the comparison between "MINOR CONGESTION" and "NORMAL CONGESTION" either. Nearly equal numbers of subject drivers believe that "MINOR CONGESTION" implies a less severe condition than "NORMAL CONGESTION" as believes the opposite. The implication of these results is that "MINOR CONGESTION" cannot be used to indicate a different level of congestion than the term "NORMAL CONGESTION."

- "MINOR CONGESTION" versus "MAJOR CONGESTION"

  2% MAJOR CONGESTION is the same as MINOR CONGESTION
  3% MAJOR CONGESTION is less severe than MINOR CONGESTION
  95% MAJOR CONGESTION is more severe than MINOR CONGESTION

For this comparison, subject drivers were in nearly complete agreement that the message "MAJOR CONGESTION" implied a more severe condition than did the message "MINOR CONGESTION."

- "MAJOR CONGESTION" versus "HEAVY CONGESTION"

  29% HEAVY CONGESTION is the same as MAJOR CONGESTION
  51% HEAVY CONGESTION is less severe than MAJOR CONGESTION
  20% HEAVY CONGESTION is more severe than MAJOR CONGESTION

For the final direct comparison, subject drivers were once again in less agreement. A simple majority (51 percent) of subject drivers did perceive the term "HEAVY CONGESTION" to indicate a less severe condition than "MAJOR CONGESTION." The remainder of subject drivers were divided as to whether "HEAVY CONGESTION" implied a more severe or equally severe condition as "MAJOR CONGESTION." The implication of these results is that "HEAVY CONGESTION" cannot be used to indicate a different level of congestion than the term "MAJOR CONGESTION" or vice-versa.

The study results by city for all questions are shown in Tables B-15 through B-29 in Appendix B.

Recommendations

An overall comparison of the results of this study is presented in Table 9-4. From this table, it appears that subject drivers basically distinguished between two distinct levels of congestion:

- Conditions that can be characterized using the messages CONGESTION, NORMAL CONGESTION, or MINOR CONGESTION; and
- Conditions that can be characterized using the messages HEAVY CONGESTION or MAJOR CONGESTION.

Within each level, slightly different interpretations may exist across messages for one or two of the traffic parameters, but these differences do not manifest themselves across all parameters. From a driver's perspective, the greatest amount of agreement as to a message's meaning was achieved in terms of the amount of delay implied. Less agreement was evident in terms of subject drivers' interpretations of the average downstream speed or length of congestion implied by the message (as evident by cumulative distribution curves that were more gradual and gentle sloping).

Table 9-4. Summary of Differences between Messages.

Traffic Parameter	Relative Differences Between Messages (for the Average Subject Driver)
Delay	NORMAL CONGESTION = MINOR CONGESTION = CONGESTION All of the above < HEAVY CONGESTION HEAVY CONGESTION < MAJOR CONGESTION
Speeds	MINOR CONGESTION = CONGESTION MINOR CONGESTION = NORMAL CONGESTION CONGESTION < NORMAL CONGESTION HEAVY CONGESTION < CONGESTION MAJOR CONGESTION < HEAVY CONGESTION
Length of Congestion	NORMAL CONGESTION = MINOR CONGESTION = CONGESTION All of the above < HEAVY CONGESTION HEAVY CONGESTION = MAJOR CONGESTION

The notion of a pair of descriptors such as MINOR CONGESTION and MAJOR CONGESTION is somewhat attractive to denote traffic conditions within major urban areas of Texas. However, it is known that some TxDOT TMCs already utilize the terms MINOR and MAJOR to describe accident severity and other conditions. To avoid confusion and overlap with these descriptors, it may be more feasible to use the single term CONGESTION for less severe congestion conditions, and the message HEAVY CONGESTION to indicate conditions that involve more than 35 minutes of delay or downstream operating speeds that are less than 25 mph. TTI researchers recommend that congestion messages not be used to try and convey approximate lengths of congestion to motorists.

10. USE OF THE TERM "HIGH-PROFILE VEHICLES"

Study Description

Questions Being Investigated

Some TxDOT districts are currently displaying the term "HIGH-PROFILE VEHICLES" to warn motorists who are driving high-profile vehicles of high winds. However, it is not known whether motorists clearly understand the meaning of the term.

Message Tested

To determine motorists' understanding of the term "HIGH-PROFILE VEHICLES," subjects were shown the message below:

HIGH WINDS
HIGH-PROFILE VEHICLES
REDUCE SPEED

Study Protocol

Participants were told to assume they were driving in an area that is susceptible to high winds from time to time. After presentation of the message, subjects were shown a list of different vehicle types and asked to select all vehicle types to which they believed the term "HIGH-PROFILE VEHICLE" applied.

Study Results

Driver interpretation of what type of vehicle they would select as a "HIGH-PROFILE VEHICLE" is shown in Table 10-1. The results indicate that over 75 percent of the subject drivers considered mobile homes and semi-trailer trucks as high-profile vehicles. While most drivers selected a semi-trailer truck as a high-profile vehicle, it is possible that more subject drivers would have chosen this vehicle type if the term "18-wheeler" had been used instead of semi-trailer truck. Additionally, 71 percent selected trailers and 69 percent selected fifth-wheel mobile homes as high-profile vehicles. The drivers' opinion on the classification of the delivery truck and sport utility vehicle was more divided with 64 percent and 43 percent, respectively, selecting those vehicles as high-profile vehicles.

The study results by city are shown in Table B-30 in Appendix B.

Table 10-1. Which of the Following Does the Term "High-Profile Vehicle" Apply To?

Vehicle Type	Selected as a High-Profile Vehicle (%)
Mobile Home	80
Semi-trailer Truck	76
Trailer	71
Fifth-Wheel Mobile Home	69
Delivery Truck	64
Sport Utility Vehicle (SUV)	43
Pickup Truck	24
Car	9
None of the above	10

n=260

Recommendations

The majority of the motorists felt that mobile homes, semi-trailer trucks, trailers, and fifth-wheel mobile homes were high-profile vehicles. Additionally, most drivers agreed that a pickup truck and a car were not high-profile vehicles. Therefore, the use of the message "HIGH-PROFILE VEHICLES" to advise drivers of mobile homes, fifth-wheels, semi-trailer trucks, and other relevant vehicles to slow down in areas where high winds exist does appear to be justified at this time.

11. FLASHING AN ENTIRE SINGLE-FRAME MESSAGE

Study Description

Questions Being Investigated

Several TxDOT districts now operating DMSs are interested in continuously flashing certain single-frame messages (typically those that describe significant traffic disruptions downstream) to approaching motorists. It is the belief of system operators that such a practice emphasizes that the message is especially important to drivers and should be heeded. Presently, it is not known whether this practice:

- affects a driver's ability to properly comprehend the message,
- affects the amount of time it takes a driver to read and comprehend the message, or
- whether drivers indeed perceive a flashing message as indicative of information that is more important.

Messages Tested

To evaluate these questions, TTI researchers conducted an experiment where subject drivers in each of the study cities viewed the following three-unit single-frame messages one at a time:

MAJOR ACCIDENT
AT *[Location]*
3 LANES CLOSED

or

FREEWAY BLOCKED
AT *[Location]*
USE OTHER ROUTES

The *[Location]* term was changed to an actual physical location name on a freeway in each study city. Subject drivers in each city saw each message presented in a static mode and also in a flashing mode.

Study Protocol

The study was counterbalanced such that one-half of the subject drivers saw a message first in a static mode and then in a flashing mode (the second viewing of the message occurred a

significant time later in the overall laboratory session for that subject driver). Conversely, the other one-half of the subject drivers saw the message first in a flashing mode and then in a static mode later on in the session.

The study was also counterbalanced with respect to whether the viewing time for the message was fixed at 8 seconds or self-paced where the subject drivers viewed the message and then turned the message off when they understood what the message said. In this way, the effect of the flashing process on both driver comprehension and required reading time could be evaluated in an objective fashion.

After presentation of each message in either a static or flashing mode for either a fixed or a self-paced period of time, subject drivers were asked to answer three questions:

1. What is the traffic problem?
2. Where is the traffic problem located?
3. What was told about the lanes (for the "3 LANES CLOSED" message) or what are you to do (for the "USE OTHER ROUTES" message)?

Study Results

Effect on Motorist Comprehension

The results of the study upon motorist comprehension are presented in Tables 11-1 through 11-3. These tables correspond to each of the three questions that were asked after each message presentation. Generally speaking, the results indicate that flashing a single-frame message does not adversely affect motorist comprehension to a significant degree. As noted in Table 11-1, nearly equal percentages of subject drivers overall correctly responded to the question "what is the traffic problem?" regardless of whether the message was presented in a static or in a flashing mode. There were some differences depending on whether or not the subject drivers viewed the message for a fixed period of time or saw the message for as long as they wanted, but these differences were identical for both the static and the flashing message presentation modes. It is not known exactly why the self-paced display time actually resulted in lower correct responses than the fixed display time.

The responses to the question about traffic problem location described in the message are summarized in Table 11-2. Again, no statistically significant differences were found between the static and the flashing message presentation modes. Furthermore, responses were also consistent between the fixed and the self-paced display times.

Finally, subject drivers' responses to the question "What are you to do?/What is told about the lanes?" are summarized in Table 11-3. No significant differences existed between static versus flashing message presentation or between fixed and self-paced display times.

The study results by city are shown in Tables B-31 through B-42 in Appendix B.

Table 11-1. Responses to the Question "What Is the Traffic Problem?"

Responses	Fixed 8-Second Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	Static Message	Flashing Message	Static Message	Flashing Message	Static Message	Flashing Message
✔ Correct answer	86[a]	89[a]	78[a]	80[a]	82	84
Incorrect answer	9	5	15	11	12	8
Did not remember	4	5	5	8	5	7
Did not respond	1	1	2	1	1	1

n=260

[a] percent of correct responses differ significantly (α =0.05) between the fixed and the self-paced display times

Table 11-2. Responses to the Question "Where Is the Traffic Problem Located?"

Responses	Fixed 8-Second Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	Static Message	Flashing Message	Static Message	Flashing Message	Static Message	Flashing Message
✔ Correct answer	90	88	85	87	88	88
Incorrect answer	5	3	6	6	5	4
Did not remember	4	7	7	6	5	6
Did not respond	1	2	2	1	2	2

n=260

Table 11-3. Responses to the Question "What Are You to Do?/What Is Told about the Lanes?"

Responses	Fixed 8-Second Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	Static Message	Flashing Message	Static Message	Flashing Message	Static Message	Flashing Message
✔ Correct answer	84	82	87	80	85	81
Incorrect answer	10	13	8	11	9	12
Did not remember	5	4	4	8	5	6
Did not respond	1	1	2	2	1	1

n=260

Effect on Message Reading Times

Basic descriptive statistics for the reading times of subject drivers used during the self-paced portion of the study are shown in Table 11-4. Average reading time of the message when it was flashing was 1.5 seconds (17 percent) longer than when the message was not flashed (i.e., the message presentation was static). The implication of these results is that drivers can process a single-frame DMS message better if the message is being presented in a static mode as opposed to a flashing mode.

Table 11-4. Reading Times for Static and Flashing Single-Frame Message (3 Units of Information).

Descriptive Statistics (n=260)	Static Message (sec)	Flashing Message (sec)	Difference (sec)
Median Reading Time	6.5	7.8	+1.3
Average Reading Time	8.6	10.1	+1.5*
Standard Deviation	8.5	8.9	+0.4

* Comparison of means test (Z=1.97) indicates difference is statistically significant ($\alpha = 0.05$)

Motorist Preferences

The final measure of comparison as to the impact of flashing a single-frame DMS message examined in this study was the perception of the subject drivers themselves. After the subject driver saw the message in both a static and a flashing presentation mode, they were asked to indicate which presentation mode they preferred and to provide some rationale for their preference. These preference data are summarized in Tables 11-5 and 11-6. Overall, TTI researchers found subject drivers to be fairly evenly split as to their preferences regarding static or flashing messages. Interestingly, preference does appear to be related to order of presentation in the study, as illustrated in Table 11-5. In particular, if subject drivers were initially presented a static message and then shown the flashing message, they tended to prefer the flashing mode. If the subject drivers were first presented a flashing message and then shown the message in a static mode, they tended to prefer the static presentation mode.

A summary of common responses received from subject drivers as to why they preferred a static or a flashing message is presented in Table 11-6. As would be expected, those who preferred a flashing message did so because they felt it was better able to get their attention. Conversely, those who preferred a static message felt that it gave them more time to read and remember the information. It was also less distracting than a flashing message.

The study results by city are shown in Tables B-43 and B-44 in Appendix B.

Table 11-5. Subject Driver Preferences for Static or Flashing Single-Frame Messages.

Preference	Static Message Presented Last (%)	Flashing Message Presented Last (%)	Both Presentation Orders Combined (%)
Static Message	53	40	47
Flashing Message	44	53	48
No Preference	3	5	4
Did not respond	0	2	1

Table 11-6. Common Reasons for Preferences of Static or Flashing Single-Frame Messages.

Reasons for Preferring a Static Message	Reasons for Preferring a Flashing Message
• Gives more time to read and understand • One simple message displayed • Can see the entire message at the same time • Easier to understand • Flashing is distracting • Flashing is confusing – I have to start over reading each time	• Gets your attention • Alerts you • Makes the incident seem more recent • Easier to remember • Keeps you focused on the problem • Gives more information

Recommendations

The results of this study indicate that flashing a single-frame three-unit message on a DMS has no significant effect upon motorist comprehension of the information being presented. Furthermore, driver preferences are fairly evenly split between flashing the message or not (i.e., a static message). However, the data show that flashing the message increases the amount of time required to read and comprehend the message. In this particular study, the fact that the message contained only three units of information allowed most subject drivers to correctly comprehend the message. However, this would not be expected to be the case if more information were presented.

Given that there does not appear to be strong driver preference for flashing single-frame messages and that such a practice does increase reading times, TTI researchers recommend that flashing messages not be used as part of DMS operations. However, if TxDOT chooses to use flashing single-frame messages, it is strongly recommended that the message themselves be limited to three units of information or less to account for the increased reading and comprehension times.

12. FLASHING ONE LINE OF A SINGLE-FRAME MESSAGE

Study Description

Questions Being Investigated

Several TxDOT districts now operating DMSs are also interested in continuously flashing one line of a single-frame message (typically the top problem statement line) to approaching motorists. It is the belief of system operators that such a practice emphasizes that the message is especially important to drivers and should be heeded. However, it is not clear what effect flashing a single line has on motorist comprehension and reading times of the entire message. For example, does the flashing line cause motorists to concentrate more on that line than the remainder of the message? Presently, it is not known whether this practice:

- affects a driver's ability to properly comprehend the message,
- affects the amount of time it takes a driver to read and comprehend the message, or
- whether drivers indeed perceive a flashing line in the message as indicative of information that is more important.

Messages Tested

To evaluate these questions, TTI researchers conducted an experiment where subject drivers in each of the study cities viewed the following three-unit single-frame messages one at a time:

FREEWAY CLOSED
AT *[location]*
FOLLOW DETOUR

or

TRUCK ACCIDENT
AT *[location]*
USE SERVICE ROAD

The *[Location]* term was changed to an actual physical location name on a freeway in each study city. Subject drivers in each city saw each message presented in a static mode and also in a flashing mode.

Study Protocol

The study order was altered among subject drivers in each city in order to counter primacy bias. The study was also counterbalanced with respect to whether the viewing time for the message was fixed at 8 seconds or self-paced where the subject drivers viewed the message and then turned the message off when they understood what the message said. In this way, the effect of flashing the top line on both driver comprehension and required reading time could be evaluated in an objective fashion.

After presentation of each message with the top line either static or flashing for either a fixed or a self-paced period of time, subject drivers were asked to answer three questions:

1. What is the traffic problem?
2. Where is the traffic problem located?
3. What are you to do?

At periodic points within the study, subject drivers were also asked to comment on which presentation style (top line static or top line flashing) that they preferred.

Study Results

Effect on Motorist Comprehension

The results of the study upon motorist comprehension are presented in Tables 12-1 through 12-3. These tables correspond to each of the three questions that were asked after each message presentation. As shown in Table 14-1, nearly equal percentages of subject drivers overall correctly responded to the question "what is the traffic problem?" regardless of whether the message was presented in a static mode or with the first line flashing. The responses were also consistent between the fixed presentation time (8 seconds) and the self-paced presentation.

The responses to the question about traffic problem location described in the message are summarized in Table 12-2. Again, no statistically significant differences were found between a static message and a message with the first line flashing. The responses were once again also consistent between the fixed and the self-paced display times.

Finally, subject drivers responses to the question "What are you to do?" are summarized in Table 12-3. For this question, the percentage of correct answers dropped significantly when the first line of the message was flashing (relative to the percentage of correct answers to that question obtained with a static message). It should be noted that the information to answer this question was listed last in the messages and was not flashing. It does appear that flashing one portion of the message may have adverse effects on a motorist's ability to remember other parts of the message.

The study results by city are shown in Tables B-45 through B-56 in Appendix B.

Table 12-1. Responses to the Question "What Is the Traffic Problem?"

Responses	Fixed 8-Second Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	Static Message	One Line Flashing	Static Message	One Line Flashing	Static Message	One Line Flashing
✔ Correct answer	78	80	74	76	76	78
Incorrect answer	12	14	17	15	15	14
Did not remember	9	5	8	8	8	7
Did not respond	1	1	1	1	1	1

n=260

Table 12-2. Responses to the Question "Where Is the Traffic Problem Located?"

Responses	Fixed 8-Second Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	Static Message	One Line Flashing	Static Message	One Line Flashing	Static Message	One Line Flashing
✔ Correct answer	92	89	91	94	91	92
Incorrect answer	6	6	3	3	5	4
Did not remember	2	5	5	2	3	3
Did not respond	0	0	1	1	1	1

n=260

Table 12-3. Responses to the Question "What Are You To do?

Responses	Fixed 8-Second Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	Static Message	One Line Flashing	Static Message	One Line Flashing	Static Message	One Line Flashing
✔ Correct answer	74	61	71	60	72	60*
Incorrect answer	16	25	18	28	17	27
Did not remember	6	11	10	10	8	10
Did not respond	4	3	1	2	3	3

n=260

* Significantly different ($Z = 4.08$) than static message response ($\alpha = 0.05$)

Effect on Message Reading Times

Basic descriptive statistics for the reading times of subject drivers for the static message and the message with one line flashing used during the self-paced portion of the study are shown in Table 12-4. Average reading time of the message when one line was flashing was 1.8 seconds (20 percent) longer than when the one line was not flashed (i.e., the message presentation was static). The implication of these results is that drivers will not be able to process as much information on a DMS if one line of the message being presented is flashing as could be processed if none of the message is flashing.

Table 12-4. Reading Times for Static and One-Line Flashing Message (3 Units of Information).

Descriptive Statistics (n=260)	Static Message (sec)	One Line Flashing (sec)	Difference (sec)
Median Reading Time	6.9	8.8	+1.9
Average Reading Time	9.2	11.0	+1.8*
Standard Deviation	8.5	9.4	+0.9

* Comparison of means test (Z=2.29) indicates difference is statistically significant ($\alpha = 0.05$)

Motorist Preferences

The final measure of comparison as to the impact of flashing one line of the DMS message examined in this study was the perception of the subject drivers themselves. After the subject drivers saw the message in both the static and the one line flashing mode, they were asked to indicate which presentation mode they preferred and to provide some rationale for their preference. These preference data are summarized in Tables 12-5 and 12-6. Overall, TTI researchers found subject drivers to be fairly evenly split as to their preferences regarding static or flashing messages. Subject driver preferences do appear to be related to order of presentation in the study, as illustrated in Table 12-5. In particular, if subject drivers were initially presented a static message and then shown the message with one line flashing, they tended to prefer the flashing mode. If the subject drivers were first presented a message with one line flashing and then shown the message in a static mode, they tended to prefer the static presentation mode.

A summary of common responses received from subject drivers as to why they preferred a static or a flashing message is presented in Table 12-6. As expected, those who preferred a flashing message did so because they felt it was better able to get their attention. Conversely, those who preferred a static message felt that it gave them more time to read and remember the information. It was also less distracting than a flashing message. A few subject drivers did comment specifically that the flashing portion of the message was the only part that they easily remembered.

The study results by city are shown in Tables B-57 and B-58 in Appendix B.

Table 12-5. Subject Driver Preferences for Static or One Line Flashing Messages.

Preference	Static Message Presented Last (%)	Flashing Message Presented Last (%)	Both Presentation Orders Combined (%)
Static Message	55	34	45
One Line Flashing	44	63	53
No Preference	1	2	1
Did not respond	0	1	1

Table 12-6. Common Reasons for Preferences of Static or Flashing Single-Frame Messages.

Reasons for Preferring a Static Message	Reasons for Preferring a Flashing Message
• Easier to read and understand • Message is clear and precise • I only remember the part that is flashing • Easier to understand • Flashing is distracting and confusing	• Gets your attention • Easier to read • Highlights the important feature • Alerts you • Emphasizes what is important

Recommendations

The results of this study indicate that flashing one line of a single-frame three-unit message on a DMS does reduce the ability of motorists to remember parts of the message that are not flashing. The data further indicate that reading times are significantly increased when the line is flashed. Driver preferences are fairly evenly split between flashing the message or not (i.e., a static message). In this particular study, the fact that the message contained only three units of information allowed most subject drivers to correctly comprehend the message. However, this would not be expected to be the case if more information were presented.

Given that there does not appear to be strong driver preference for flashing one line of a single-frame message and that such a practice reduces overall motorist comprehension and increases reading time, TTI researchers recommend that this technique not be used as part of DMS operations in Texas.

13. REDUNDANCY IN A TWO-FRAME MESSAGE

Study Description

Questions Being Investigated

Another operating practice of interest to some TxDOT districts now operating DMSs is to format a message in such a way that the top two lines of the message remain constant and a third bottom line is changed from one unit of information to the next. In essence, the DMS would operate as if it were a two-frame message, but with some of the information constant between the two frames. It is not clear what effect the redundancy of information has on motorist comprehension and reading times of the entire message. For example, do the repetitive lines cause motorists to read these lines more than once thus increasing reading times? Also, there is uncertainty whether motorists actually notice that the bottom line changes. Therefore, TTI researchers in this study focused on the following objectives:

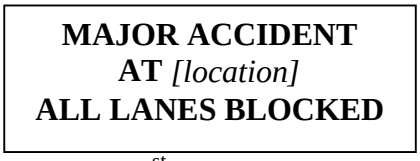
- determine motorist comprehension of redundancy in the form of repetition in a two-frame message when the bottom line changes while the other two lines remain the same versus a two-frame message without redundancy;
- determine motorist preferences for each of the two message styles; and
- determine motorist reading times for each of the two message styles.

Messages Tested

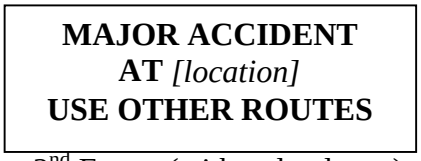
To evaluate these questions, TTI researchers conducted an experiment where subject drivers in each of the study cities viewed the following two-frame messages one at a time:

versus

or

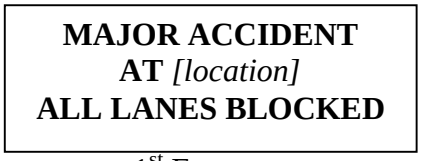


1st Frame

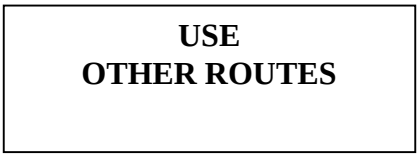


2nd Frame (with redundancy)

versus



1st Frame



2nd Frame (no redundancy)

The *[Location]* term was changed to an actual physical location name on a freeway in each study city.

Study Protocol

The study order was altered among subject drivers in each city in order to counter primacy bias. The study was also counterbalanced with respect to whether the viewing time for the message was fixed at 8 seconds or self-paced. For the self-paced evaluation, subject drivers viewed the first frame of the message, tapped the space bar to move to the second frame, and then turned the message off with another tap on the space bar when they believed they understood what the message said.

After presentation of each message, subject drivers were asked four questions:

1. How many lanes are blocked?
2. What is the traffic problem?
3. What are you told to do?
4. Where is the traffic problem located?

At periodic points within the study, subject drivers were also asked to comment on which presentation style (with redundancy or without redundancy in each frame) they preferred.

Study Results

Effect on Motorist Comprehension

The results of the study upon motorist comprehension are presented in Tables 13-1 through 13-4. These tables correspond to each of the four questions that were asked after each message presentation. As shown in Table 13-1, nearly equal percentages of subject drivers overall correctly responded to the question "how many lanes are blocked?" regardless of whether the message was presented without redundancy or with redundancy on the top two lines while the bottom line changed for each frame. The responses were also consistent (statistically speaking) between the fixed presentation time and the self-paced presentation.

The responses to the question about the traffic problem described in the message are summarized in Table 13-2. Again, no statistically significant differences were found between a message with or without redundancy and one with redundancy on the top two lines while the bottom line changed for each frame. The responses were once again also consistent between the fixed and the self-paced display times. Similar consistency was also observed in the responses to the question "What are you told to do?" as shown in Table 13-3. Finally, the summary of responses to the question "Where is the traffic problem located?" is presented in Table 13-4. As with the other questions, no statistically significant differences in responses were identified between the two test conditions (no redundancy versus with redundancy).

Table 13-1. Responses to the Question "How Many Lanes Are Blocked?"

Responses	Fixed 8-Second Display Time, 4 Seconds per Frame (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	No Redundancy	With Redundancy	No Redundancy	With Redundancy	No Redundancy	With Redundancy
✔ Correct answer	89	82	91	90	90	86
Incorrect answer	6	9	6	7	6	8
Did not remember	4	7	2	3	3	5
Did not respond	1	2	1	0	1	1

n=260

The study results by city are shown in Tables B-59 through B-74 in Appendix B.

Table 13-2. Responses to the Question "What Is the Traffic Problem?"

Responses	Fixed 8-Second Display Time, 4 Seconds per Frame (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	No Redundancy	With Redundancy	No Redundancy	With Redundancy	No Redundancy	With Redundancy
✔ Correct answer	77	81	81	81	79	81
Incorrect answer	17	14	14	12	16	13
Did not remember	5	4	4	6	4	5
Did not respond	1	1	1	1	1	1

n=260

Table 13-3. Responses to the Question "What Are You Told To Do?"

Responses	Fixed 8-Second Display Time, 4 Seconds per Frame (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	No Redundancy	With Redundancy	No Redundancy	With Redundancy	No Redundancy	With Redundancy
✔ Correct answer	67	65	72	71	70	68
Incorrect answer	19	20	16	19	18	19
Did not remember	13	12	10	8	11	10
Did not respond	1	3	2	2	1	3

n=260

Table 13-4. Responses to the Question "Where is the Traffic Problem Located?"

Responses	Fixed 8-Second Display Time, 4 Seconds per Frame (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	No Redundancy	With Redundancy	No Redundancy	With Redundancy	No Redundancy	With Redundancy
✔ Correct answer	82	72	73	82	78	77
Incorrect answer	5	13	15	7	10	10
Did not remember	10	12	10	10	10	11
Did not respond	3	3	2	1	2	2

n=260

Effect on Message Reading Times

Basic descriptive statistics for the reading times of subject drivers for the information redundancy versus no redundancy messages used during the self-paced portion of the study are shown in Table 13-5. Average reading time of the message that had redundant information in both frames was 2.8 seconds (21 percent) longer than the message that did not include redundant

information in both frames. The implication of these results is that drivers will not be able to process as much information overall on a DMS if redundant information is included.

Table 13-5. Reading Times for Two-Frame Message with and without Redundant Information in Both Frames.

Descriptive Statistics (n=260)	No Redundancy (sec)	With Redundancy (sec)	Difference (sec)
Median Reading Time	10.1	12.8	+2.7
Average Reading Time	13.4	16.2	+2.8*
Standard Deviation	12.4	14.5	+2.1

* Comparison of means test (Z=2.37) indicates difference is statistically significant ($\alpha = 0.05$)

Motorist Preferences

The final measure of comparison as to the impact of having redundant information in the DMS messages examined in this study was the perception of the subject drivers themselves. After the subject drivers saw the same message with and without redundant information included, they were asked to indicate which presentation mode they preferred and to provide some rationale for their preference. These preference data are summarized in Tables 13-6 and 13-7. Overall, TTI researchers found subject drivers to be fairly evenly split as to their preferences for having redundant information in the message (i.e., changing only one line between the two frames). Subject driver preferences do appear to be related to order of presentation in the study, as illustrated in Table 15-6. In particular, if subject drivers were initially presented a message without redundancy and then shown the message with redundancy, they tended to prefer the redundancy. If the subject drivers were first presented a message with redundancy and then shown the message without redundancy, they tended to prefer the message without redundancy.

A summary of common responses received from subject drivers as to why they preferred to have or not to have redundancy in the message is presented in Table 13-7. A few subject drivers noted that they may not notice the change in the bottom line if the top two lines of the message do not change between frames. On the other hand, those subject drivers who preferred messages with redundant information felt that the important information was reinforced with the redundancy so it was easier to remember.

The study results by city are shown in Tables B-75 and B-76 in Appendix B.

Table 13-6. Subject Driver Preferences for Redundant or No Redundancy Messages.

Preference	Message with No Redundant Information Presented Last (%)	Message with Redundant Information Presented Last (%)	Both Presentation Orders Combined (%)
With Redundancy	38	55	47
No Redundancy	57	41	49
No Preference	4	3	3
Did not respond	1	1	1

Table 13-7. Common Reasons for Preferences of Messages with or without Redundancy.

Reasons for Preferring Messages Without Redundancy	Reasons for Preferring Messages With Redundancy
• Clear and precise • Easier to read • Provides more information with less words • Saves time • Simple and direct • When top line says same thing, may not notice that bottom line changes • When bottom line changes, it makes that information seem less important	• It's more complete • Clear and precise • Easier to read • Easier to remember • Maintains [information] where problem is located • Reinforces the problem and where it is located • Able to see all relevant information at one time

Recommendations

The results of this study indicate that on three-line DMSs including redundant information by repeating the top two lines on both frames of a two-frame message while changing the bottom line does not reduce the ability of motorists to remember parts of the message. However, total message reading times are significantly increased when redundant information is included. Driver preferences are fairly evenly split between having or not having redundant information in both frames.

Given these findings, TTI researchers recommend that decisions whether or not to repeat the two frames of a four-unit message be left to the discretion of the DMS operator.

14. THREE-FRAME MESSAGES ON PORTABLE DMSs

Study Description

Questions Being Investigated

Some TxDOT districts display messages with three frames on portable DMSs. There is concern that three-frame messages are too long for motorists to read and comprehend while driving at speeds of 55 mph or greater. If this is true, messages should be limited to two frames.

TTI researchers in this study focused on the following objectives:

- determine motorist comprehension of two- and three-frame messages containing the same amount of information on eight-character portable DMS;
- determine motorist preferences for either the two-frame or three-frame presentation format; and
- determine motorist reading times for each of the two presentation formats.

Messages Tested

In this experiment, subject drivers were presented four-unit messages containing the same information but formatted as either a two-frame or three-frame message that could be displayed on a three-line, eight-character per line portable DMS. Messages that were used in the study were shown below:

ROADWORK **AT** *[location 1]*	*[destination]* **USE** *[location 2]*
1st Frame	2nd Frame

versus

ROADWORK **AT** *[location 1]*	**USE** *[location 2]*	**TO** *[destination]*
1st Frame	2nd Frame	3rd Frame

The *[Location]* term was changed to an actual physical location name on a freeway in each study city. The term "ROADWORK" was also changed for one-half of the subject drivers to read "LEFT LANE CLOSED."

Study Protocol

The study order was altered among subject drivers in each city to counter primacy bias. The study was also counterbalanced with respect to whether the viewing time for the message was fixed at 8 seconds (total for both the two- and three-frame messages) or self-paced. For the self-paced evaluation, subject drivers viewed the first frame of the message, tapped the space bar to move to the second frame, pressed the space bar again if there was a third frame, and then turned the message off with another tap on the space bar when they believed they understood the message.

After presentation of each message, subject drivers were asked four questions:

1. What is the traffic problem?
2. What should drivers do who are going to the destination?
3. Where on the highway is the traffic problem located?
4. What destination is on the sign?

At periodic points within the study, subject drivers were also asked to comment on which presentation style (two frame or three frame) that they preferred.

Study Results

Effect on Motorist Comprehension

The results of the study upon motorist comprehension are presented in Tables 14-1 through 14-4. These tables correspond to each of the four questions that were asked after each message presentation. As shown in Table 14-1, nearly equal percentages of subject drivers overall correctly responded to the question "What is the traffic problem?" regardless of whether the message was presented in two or three frames. It should be noted that this particular unit of information was not well remembered by subject drivers under either presentation formats (less than one-half of the subject drivers responded correctly to this question). The responses were also consistent (statistically speaking) between the fixed presentation time and the self-paced presentation.

The responses to the question about what should drivers do are summarized in Table 14-2. Again, no statistically significant differences were found between a two-frame and a three-frame message. However, a higher percentage of subject drivers (slightly less than 70 percent) did respond correctly to this question. Differences were found between presentation formats as seen in the responses to the question "Where is the problem located?" shown in Table 14-3. Specifically, a significantly higher percentage of motorists correctly answered that question

when viewing the information in a two-frame format. Finally, the summary of responses to the question "What destination is on the sign?" is presented in Table 14-4. Once again, no statistically significant differences in responses were identified between the two presentation formats (two-frame versus three-frame message).

The study results by city are show in Tables B-77 through B-92 in Appendix B.

Table 14-1. Responses to the Question "What Is the Traffic Problem?"

Responses	Fixed 8-Second Total Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message
✔ Correct answer	46	39	36	41	41	40
Incorrect answer	33	39	43	37	38	38
Did not remember	18	20	20	19	19	19
Did not respond	3	2	1	3	2	3

n=260

Table 14-2. Responses to the Question "What Should Drivers Do?"

Responses	Fixed 8-Second Total Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message
✔ Correct answer	68	65	65	73	67	69
Incorrect answer	22	20	21	17	21	19
Did not remember	8	14	13	7	10	10
Did not respond	2	1	1	3	2	2

n=260

Table 14-3. Responses to the Question "Where Is the Problem Located?

Responses	Fixed 8-Second Total Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message
✔ Correct answer	79	67	78	73	78	70*
Incorrect answer	8	14	12	11	10	12
Did not remember	10	15	8	13	9	14
Did not respond	3	4	2	3	3	4

n=260

* Significantly (Z=2.08) different than 2-frame message ($\alpha = 0.05$)

Table 14-4. Responses to the Question "What Destination Is on the Sign?"

Responses	Fixed 8-Second Total Display Time (%)		Self-Paced Display Time (%)		Display Time Types Combined (%)	
	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message	2-Frame Message	3-Frame Message
✔ Correct answer	72	70	67	73	70	72
Incorrect answer	19	19	22	20	20	20
Did not remember	8	9	8	6	8	7
Did not respond	1	2	3	1	2	1

n=260

Effect on Message Reading Times

Table 14-5 shows basic descriptive statistics for the reading times of subject drivers for the two-frame and three-frame presentation formats during the self-paced portion of the study. Median and average reading times are essentially identical between the two-frame and three-frame presentation formats.

Table 14-5. Reading Times for Two-Frame and Three-Frame Message.

Descriptive Statistics (n=260)	2-Frame Message (sec)	3-Frame Message (sec)	Difference (sec)
Median Reading Time	11.4	11.5	+0.1
Average Reading Time	15.4	15.2	-0.2
Standard Deviation	13.7	13.3	-0.4

Motorist Preferences

The final measure of comparison is the subject driver preferences. As Table 14-6 illustrates, subject drivers preferred the two-frame presentation format above the three-frame format by more than a three-to-one margin. This result was found to be the case regardless of whether the subject drivers viewed the two-frame or three-frame last in the study sequence.

Table 14-7 presents a summary of common responses received from subject drivers as to why they preferred the two-frame or three-frame presentation format. A few subject drivers noted that the two-frame message did not change from frame to frame as fast as the three-frame message (remember that both presentation formats cycled through all frames in 8 seconds). On the other hand, those subject drivers who preferred the three-frame messages liked that the information was more distributed across the frames and was not as "crammed."

The study results by city are shown in Tables B-93 and B-94 in Appendix B.

Table 14-6. Subject Driver Preferences for Two-Frame or Three-Frame Messages.

Preference	Two-Frame Message Presented Last (%)	Three-Frame Message Presented Last (%)	Both Presentation Orders Combined (%)
Two-Frame Message	72	66	69*
Three-Frame Message	21	32	27
No Preference	3	0	1
Did not respond	4	2	3

* Preference Percentage for Two-Frame and Three-Frame Messages are Significantly (Z=7.32) Different ($\alpha = 0.05$)

Table 14-7. Common Reasons for Two-Frame or Three-Frame Messages.

Reasons for Preferring Two-Frame Message	Reasons for Preferring Three-Frame Message
• More time to read each frame • Frames are not flashing as fast • Three-frame message [appeared to] have too much information • The fewer the number of frames, the better I understand • Message [frames] appear more complete	• Terminology on two-frame message was confusing • Makes more sense • Not as much information all at once • Two-frame messages are too "crammed"

Recommendations

The results of this study indicate that the three-frame message may result in slightly lower comprehension levels (as suggested by the differences in responses shown in Table 14-3) for certain units of information. However, TTI researchers did not detect any significant differences in reading times between the two presentation formats. Perhaps of most significance to this study was the fact that subject drivers strongly preferred the two-frame format above the three-frame format. It should also be noted that the Federal Highway Administration (FHWA) Docket for the revised Part VI of the Manual on Uniform Traffic Control Devices limits portable DMS displays to two frames. Based on the findings from this study, TTI researchers recommend that TxDOT and its contractors use a two-frame presentation format on a portable DMS instead of a three-frame format.

15. REPEATING THE DISPLAY OF A TWO-FRAME MESSAGE ON PORTABLE DMSs

Study Description

Questions Being Investigated

Some TxDOT districts increase the sequence rate for two-frame messages on portable DMSs in order for drivers traveling 55 mph to view them twice within an 8-second time period (2 seconds per frame). This study was designed to determine if this method is acceptable as compared to using a longer sequence rate where drivers traveling at 55 mph view the message only one time within an 8-second time period (4 seconds per frame). TTI researchers in this study focused on the following objectives:

- Determine motorist comprehension when displaying a two-frame message displaying each frame for 4 seconds.
- Determine motorist comprehension when displaying the same two-frame message displayed 2 seconds per frame with the entire message repeated.
- Determine motorist preferences for either the 4 seconds per frame message or the repeated 2 seconds per frame message.

Messages Tested

Subject drivers were presented the four-unit message below containing the same information but displayed either as a two-frame message with each frame shown for 4 seconds, or the same two-frame message shown for 2 seconds each and the entire message repeated once.

FREEWAY **BLOCKED** *[location 1]*	*[destination]* **USE** *[location 2]*
1st Frame	2nd Frame

or

ROADWORK **AT** *[location 1]*	*[destination]* **USE** *[location 2]*
1st Frame	2nd Frame

The *[Location]* and [*destination]* terms were changed to actual physical location names on a freeway in each study city.

Study Protocol

Subject drivers viewed the same two-frame message displayed with the two sequencing times. The first two-frame message was shown once (no repetition) with each frame exposed for 4 seconds. The same two-frame message was shown again during another part of the overall laboratory session with the exception that each frame was displayed for 2 seconds with one repetition. The order of the message presentation was counter-balanced by showing half the drivers the no repetition message first and the other half the one repetition message first.

After the drivers had viewed both sequencing rates, they were shown the message styles again, one at a time, and asked to comment on which message style they preferred.

After the presentation of each message, subject drivers where asked four questions:

1. What is the traffic problem?
2. Where is the traffic problem located?
3. What destination is on the sign?
4. What should drivers do who are going to the destination?

Study Results

Effect of Motorist Comprehension

The subject drivers responses to the question "What is the traffic problem?" are summarized in Table 15-1. In general, nearly equal percentages of subject drivers correctly responded, regardless of whether the message frames were shown once or repeated.

The responses to Question 2, "Where is the traffic problem?" are presented in Table 15-2. While the correct response percentages increased from Question 1, no significant differences were found between the two message modes. Participants correctly responded to the no-repetition message 82 percent of the time, whereas the message with a repetition had a 78 percent correct response rate from the subject drivers.

Responses to the question "What destination is on the sign?" are summarized in Table 15-3. The repeated message had a correct response rate of 57 percent, whereas the message without the repetition only generated correct responses from 48 percent of the subject drivers. This difference between the percent of correct responses was statistically significant.

The results for the question "What should drivers do who are going to the destination?" are presented in Table 15-4. The table also shows a significant difference between the two presentation formats. A significantly higher percentage (61 percent) of motorists correctly answered that question when the message was not repeated. Only 51 percent of the correct

responses were recorded for subject drivers who viewed the message repeated in 2-second intervals.

The study results by city are shown in Tables B-95 through B-102 in Appendix B.

Table 15-1. Response to the Question "What Is the Traffic Problem?"

Responses (n=260)	Message with no repetition (%)	Message with repetition (%)
✔Correct answer	68	64
Incorrect answer	20	20
Did not remember	11	13
Did not respond	1	3

Table 15-2. Response to the Question "Where Is the Traffic Problem?"

Responses (n-260)	Message with no repetition (%)	Message with repetition (%)
✔Correct answer	82	78
Incorrect answer	8	10
Did not remember	9	8
Did not respond	1	4

Table 15-3. Response to the Question "What Destination Is on the Sign?"

Responses (n=260)	Message with no repetition (%)	Message with repetition (%)
✔Correct answer	48*	57*
Incorrect answer	21	17
Did not remember	28	21
Did not respond	3	5

*Comparison of means test (Z=2.51) indicates difference is statistically significant (α=0.05)

Table 15-4. Response to the Question "What Should Drivers Do Who Are Going to the Destination?"

Responses (n=260)	Message with no repetition (%)	Message with repetition (%)
✔Correct answer	61*	51*
Incorrect answer	18	24
Did not remember	18	21
Did not respond	3	4

*Comparison of means test (Z=2.30) indicates difference is statistically significant (α=0.05)

Motorist Preferences

Subject driver preferences for the two message presentation sequences are shown in Table 15-5. Overall, TTI researchers found subject drivers to be fairly evenly split as to their message style preference. As the data in the table indicate, the subject drivers were more likely to select the message that they had viewed last in the study as their preference.

A summary of the responses received from the subject drivers as to why they preferred the two-frame message displayed once or the two-frame message displayed with repetition is presented in Table 15-6. Those that preferred the no-repetition message felt that the other message mode was distracting and confusing. In contrast, those who preferred the repeated two-frame message felt that the flashing got your attention, and that it gave you a second opportunity to read the message if you missed the message frames display the first time.

The study results by city are shown in Tables B-103 and B-104 in Appendix B.

Table 15-5. Subject Driver Preferences for No Repetition or with Repetition Messages.

Response	Message With No Repetition Presented Last (%)	Message With Repetition Presented Last (%)	Both Presentation Orders Combined (%)
Message with No Repetition	52	38	45
Message with Repetition	33	52	43
No Preference	15	8	11
Did not respond	0	2	1

Table 15-6. Common Reasons for Preferences of Message with No Repetition or Message with Repetition.

Message with no repetition	Message with Repetition
• Easier to read • Gives more time to read • Other style is too fact • Confusing when flashing • Easier to comprehend • Flashing is distracting	• Gets your attention • Information displayed faster • More time to read • Message more frequent • If you miss the first time, you can read it on the second flash

Recommendations

The data in Table 15-3 imply that comprehension may increase when repeating a message within a motorist's available viewing time. However, TTI researchers believe that the results in Table 15-3 came at the expense of the other information provided in the message. Note in particular the significantly lower correct response rate for the information being queried in Table 15-4. In that table, motorists were better able to recall that information in the no-repetition message.

Given that there does not appear to be strong driver preference for having information repeated in shorter intervals, TTI researchers recommend that repeating the frames of a four-unit message be left to the discretion of the DMS operator.

16. COMPARISON BETWEEN FOUR UNITS OF INFORMATION ON ONE FRAME VERSUS TWO FRAMES

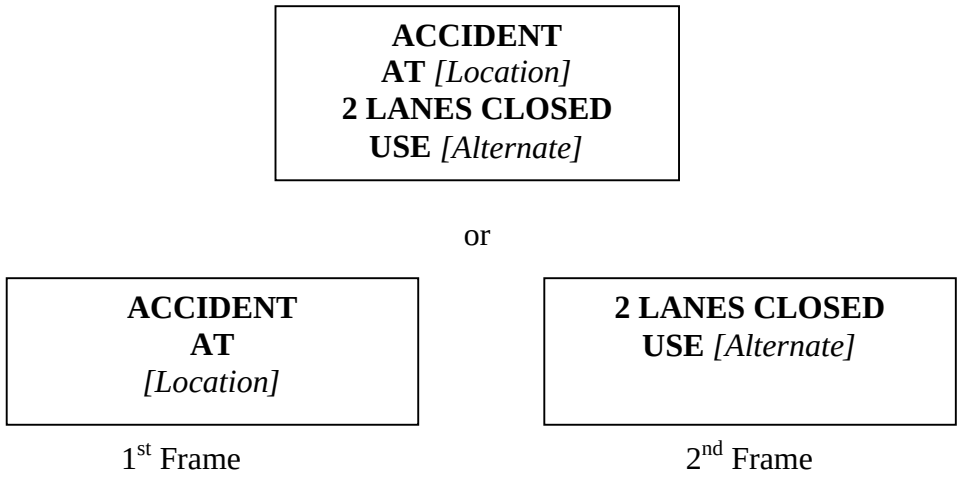
Study Description

Questions Being Investigated

Some four-unit messages can be either displayed on one message frame or two message frames. The question is whether splitting the message over two frames improves motorists' comprehension. The objective of this study was to determine whether it is best to display a four-unit message on one-frame (if sign size permits) or on two frames.

Messages Tested

An experiment was developed where subjects viewed the following sample sign messages on the computer screen and responded to questions to measure their comprehension:



The *[Location]* and *[Alternate]* terms were specific to each of the five cities where the studies were conducted. Subject drivers in each city saw the message presented in a one-frame message and in the two-frame message mode.

Study Protocol

To avoid primacy bias, order of the messages was changed such that half of one group was presented the four-unit message on a single frame first; and the other half of the same group

received a similar message presented in a two-frame message mode first. Conversely, the other group saw the four-unit message on two-frames first and on a single frame later on in the study session. The single frame message was displayed for 8 seconds, while the two-frame message was displayed in two increments of 4 seconds each. Comprehension for both groups was measured by asking questions about the message.

After reviewing each message in either a one-frame or two-frame message mode, the following questions were asked:

1. What is the traffic problem?
2. Where is the traffic problem?
3. How many lanes are closed?
4. What should you do?

After each message was viewed, the drivers were shown both messages again, one at a time, and asked to comment on which message they preferred and why.

Study Results

Effect on Motorists Comprehension

The drivers' responses to the question as to what was the problem are summarized in Table 16-1. In general, subject drivers correctly responded to the question in nearly identical percentages for both presentation formats (92 percent for one-frame message versus 90 percent for the two-frame message).

The responses to Question 2 as to where the problem was located are presented in Table 16-2. Again, there does not seem to be any significant difference between the two messages. The one-frame message generated 83 percent correct responses, while the two-frame message generated 85 percent correct responses from subject drivers.

The responses to the question about how many lanes are closed are summarized in Table 16-3. Statistically significant differences were detected for this particular question. The one-frame message generated 79 percent correct responses, whereas the two-frame message generated only 70 percent correct responses.

Responses to the last question asking the subject driver "What should you do?" are summarized in Table 16-4. Once again, no significant differences were detected between the two message formats.

The study results by city are shown in Tables B-105 through B-112 in Appendix B.

Table 16-1. Response to the Question "What Is the Problem?"

Responses	One-Frame Message (%)	Two-Frame Message (%)
✔Correct answer	92	90
Incorrect answer	6	8
Did not remember	2	2

n=260

Table 16-2. Response to the Question "Where Is the Traffic Problem*?"*

Responses	One-Frame Message (%)	Two-Frame Message (%)
✔Correct answer	83	85
Incorrect answer	8	4
Did not remember	8	8
Did not respond	1	3

n=260

Table 16-3. Response to the Question "How Many Lanes Are Closed?"

Responses	One-Frame Message (%)	Two-Frame Message (%)
✔Correct answer	79*	70*
Incorrect answer	12	16
Did not remember	8	12
Did not respond	1	2

n=260

* Comparison of means test (Z=1.96) indicates difference is statistically significant (α=0.05)

Table 16-4. Response to the Question "What Should You Do?"

Responses	One-frame Message (%)	Two-frame Message (%)
✔Correct answer	63	70
Incorrect answer	24	17
Did not remember	10	11
Did not respond	3	2

n=260

Motorist Preferences

Subject drivers were also asked to indicate which message format style they preferred and why. Table 16-5 summarizes the preference data received. Overall, 60 percent of the drivers preferred the one-frame message. Only 38 percent preferred the two-frame message.

General trends were fairly consistent regardless of whether subject drivers were presented the one-frame or the two-frame message last before being asked their preference.

Table 16-5. Subject Driver Preferences for One-Frame Message Style or Two-Frame Message Style.

Response	Shown One-Frame Message Last (%)	Shown Two-Frame Message Last (%)	Total
One-frame message	69	51	60
Two-frame message	28	47	38
No Preference	2	1	1
Did not respond	1	1	1

Table 16-6 presents a summary of the responses received from the subject drivers as to why they preferred the one-frame message or the two-frame message. Those that preferred the one-frame message did so because they preferred to receive all the information at once and felt they had more viewing time. It was also mentioned by some that the two-frame message seemed to imply two traffic problems rather than one. In contrast, those who preferred the two-frame message felt that the message was not as cluttered, making it easier to read.

The study results by city are shown in Tables B-113 and B-114 in Appendix B.

Table 16-6. Common Reasons for Preferences of One-Frame or Two-Frame Message.

Reasons for Preferring a One-Frame Message	Reasons for Preferring a Two-Frame Message
• Information given all at once • Easier to read and understand • Easier to remember • Stays on screen longer • Flashing distracts me • Tells you everything at once, do not have to wait for the second sign • Seems like there are two problems if divided into two messages • Gives you more time to read	• It's split in two parts • Easier to read and understand • Too much information for one sign • Less information to assimilate and process at one time • Less confusing • Other sign was too cluttered • Less to read at one time • If you miss the first sign, you can catch the second one

Recommendations

The results of this study indicate that splitting a message over two frames does not seem to improve motorists' comprehension. As shown in Table 16-3, the results indicate that the two-frame message may result in more motorists not remembering some key information from the

message. In addition, the majority of the subject drivers (60 percent) preferred the one-frame message to the two-frame message. Based of these findings, TTI researchers recommend that a one-frame message be used when possible.

17. EFFECT OF REDUNDANT LANE CLOSURE INFORMATION ON DMSs WHEN LANE CONTROL SIGNALS ARE USED TO CONVEY LANE CLOSURES

Study Description

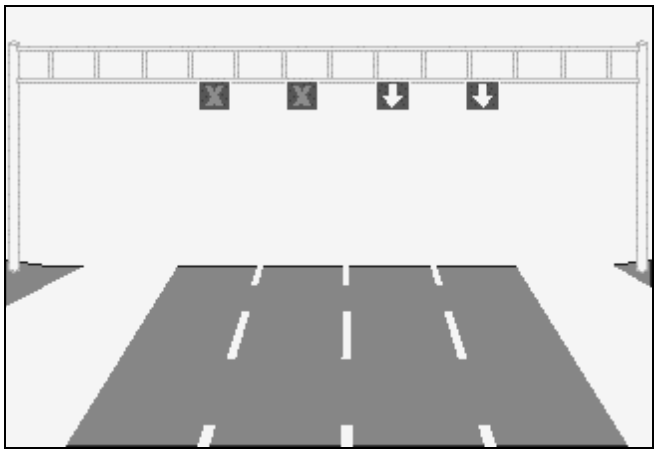
Questions Being Investigated

Several TxDOT districts have installed both DMSs and lane control signals (LCSs) along sections of their urban freeways for traffic management purposes. According to past research on DMSs, one of the most critical units of information that drivers need and desire to know is the location of any lane blockages or closures downstream. In the absence of LCSs, this information would be displayed to drivers on the DMS. However, if LCSs are present, TxDOT operators question whether they should display:

- downstream lane condition information (i.e., lanes are closed) that is redundant with that shown on the LCS, or
- other information that motorists cannot obtain from the LCSs (location of lane closure, travel time delays, etc.).

Study Protocol

To evaluate these questions, TTI researchers conducted a two-part experiment where subject drivers in each of the study cities viewed the following sketch that depicted a four-lane freeway with a sign bridge with LCSs mounted underneath:



The figure was presented in color and depicted two red X's over the left two lanes and two green arrows over the right two lanes. Subject drivers in each city were asked to picture

themselves driving on the freeway shown and seeing the LCSs, and then answer the following two questions:

1. What information do the red X's and green arrows give to you?
2. What driving action would you take if you were driving in the far left lane?

After answering the above questions, subject drivers were then shown the following message and asked to picture that a DMS was also located next to the freeway shown in the previous sketch and was displaying the following message:

ACCIDENT
AHEAD

Subjects were then asked two more questions:

1. What **new** information does the electronic sign give to you that you did not get from the information in the sketch?
2. If you were driving on the highway and saw the red X's, green arrows, and the electronic sign shown on the screen, what other information would you need on the sign to make your driving decisions?

Study Results

Summaries of responses obtained after subjects were shown the first sketch and asked what information the red X's and green arrows over the lanes provide, and what driving action drivers should take if traveling in the left lane are presented in Table 17-1. The responses indicate that the majority of Texas motorists correctly perceive the symbols to indicate the presence of some lane blockage or lane closure downstream, and know they were to move from the leftmost lane to one of the lanes under a green arrow. The high degree of understanding (96 percent) of the lane control signals is consistent with earlier studies conducted by TTI for TxDOT *(17)*.

Subject driver responses after being shown the DMS message and asked what new information was provided by the sign that they did not receive from the sketch are summarized in Table 17-2. As the table indicates, 87 percent of the subject drivers identified "accident" as the new information provided by the sign.

A summary of responses to the final question is provided in Table 17-3. Interestingly, the single greatest proportion of subject drivers (36 percent) indicated that they did not need any additional information beyond that provided by the LCS and the "ACCIDENT AHEAD" message on the DMS. Fourteen percent stated that they would like to see which lanes are closed,

which would be redundant with the LCSs. Meanwhile, 50 percent of the subject drivers stated that other additional information would be useful. Information about the approximate distance to the accident was cited as needed information by 14 percent of subject drivers. Finally, smaller proportions of subject drivers indicated a preference for general caution information to be shown (7 percent) or to provide information on expected travel times, magnitudes of delays, or average speeds downstream (5 percent).

The study results by city are shown in Tables B-115 through B-118 in Appendix B.

Table 17-1. Responses to Questions "What Information Do the Red X's and Green Arrows Give To You?" and "What Driving Action Would You Take If You Were Driving in the Far Left Lane?"

Responses	Information Provided by Red X and Green Arrow (%)	Proper Driving Action to Take (%)
✔ Correct answer	96	92
Incorrect answer	3	7
Did not remember	1	1
Did not respond	0	0

n=260

Table 17-2. Responses to Question "What <u>New</u> Information Does the Electronic Sign on the Screen Give to You That You Did Not Get from the Information on the Sketch?"

Responses	% of Subject Drivers
"Accident"	87
Other information	10
Did not remember	2
Did not respond	1

n=260

Table 17-3. Responses to Question "What Other Information Would You Need on the Sign to Make Driving Decisions?"

Responses	% of Subject Drivers
• Nothing else	36
• Distance to accident	14
• Which lanes are closed	14
• That I should be careful, slow down, use caution	7
• The expected travel times, amount of delay, or speeds downstream	5
• Other miscellaneous responses*	24

n=260

* no other single category contained more than 5 percent of the responses

Recommendations

The results of this study indicate that motorists are capable of extracting key information about a downstream lane blockage from a combination of lane control signals and dynamic message signs. These results suggest that it is possible to rely on the LCS to indicate which lanes are blocked or closed, and utilize the DMS to provide other key information (what is the problem, how far downstream the problem is located, etc.). However, there are those motorists who indicate a desire for lane status information on the DMS, even if the LCSs are displaying that information as well. TTI researchers recommend that redundant information about lane status be presented on a DMS in conjunction with LCS if no other important information is available to provide motorists. That is, that lane closure information should be presented on the DMS even when LCSs are present rather than simple caution or advisory information instead (i.e., "EXPECT DELAY" or "USE CAUTION").

18. SUMMARY AND RECOMMENDATIONS

This report provided the results of an extensive laboratory investigation of a total of 15 specific issues related to DMS operations statewide. These issues were identified and approved by TxDOT project advisors responsible for DMS operations in their respective districts. TTI researchers then recruited 260 Texas drivers from across the state to participate in laboratory sessions. Laptop computers were used to simulate DMS message displays. After each message display, participating subject drivers responded to questions designed to determine the level of recall and comprehension of the information contained in the message. Response times as well as message format/sign operating preferences were also collected from the subject drivers. Based on these data, a number of specific recommendations regarding these issues could be made. These recommendations are presented below.

Alternative Messages for Communicating Time and Day for Roadwork

- *Actual days of the week (e.g., TUES – FRI) should be used when the message is displayed for a work activity that will occur within the upcoming week.* The results of this study illustrated that drivers have difficulties in corresponding calendar dates (e.g., JAN 25 – JAN 28) with specific days of the week.

- *Actual days of the week (e.g., THURS THRU WED) should also be used in place of the term "FOR 1 WEEK."* The results of this study indicate that the drivers had difficulty identifying which days were meant by the term "FOR 1 WEEK." This recommendation does imply that the message must be changed daily to maintain accuracy.

- *The message term "WEEKEND" should be used only if the work is to start on Saturday morning and end by Sunday evening at midnight.* The results indicate that most drivers felt that the term "WEEKEND" meant the work would start and end at these times. Actual days and hours should be displayed on the DMS if work is to begin on Friday evening and/or continue into Monday morning.

Interpretation of Certain Words or Phrases

- *When displaying current travel times on DMSs, the time-of-day that the travel time was measured should be included in the message (i.e., "TRAVEL TIME TO DOWNTOWN – 20 MINUTES AT 7:20 AM").* The results of the study suggest that only about 10 percent of motorists interpret the travel time on the DMS to mean exactly the time shown regardless of whether the time-of-day was also displayed in the sign. However, a travel time message displaying the time-of-day when the travel time was measured may help some motorists use their local knowledge to predict a current travel time for themselves based on when that most recent travel time information was gathered. Although not measured directly in this study, it is believed that this ability yields the DMS operating agency (i.e., TxDOT) more credibility with the driving public.

- *The word "EXIT" should be used when referring to an exit ramp on a freeway (i.e., "EXIT CLOSED"); the word "RAMP" should not be used when referring to an exit ramp on a freeway*. Subject drivers interpreted "RAMP" to mean an entrance to a freeway and not an exit from a freeway.

- *The route or interstate designation (I-, US, SH, FM) should always be used along with the number when referring to a roadway*. The use of the route number alone on a DMS may be confusing to local drivers and will most likely be confusing to drivers from other states.

- *Since CONGESTION and HEAVY CONGESTION were found to mean approximately the same thing as MINOR and MAJOR CONGESTION, respectively, these terms are recommended for use on DMS in Texas.* The use of a pair of congestion descriptors such as MINOR CONGESTION and MAJOR CONGESTION is somewhat attractive to denote traffic conditions within major urban areas of Texas. However, it is known that some TxDOT TMCs already utilize the terms MINOR and MAJOR to describe accident severity and other conditions.

- *It is appropriate to use the term "HIGH-PROFILE VEHICLES" when referring to vehicles that may be difficult to control by drivers in high cross winds.* The majority of the motorists felt that mobile homes, semi-trailer trucks, trailers, fifth-wheel mobile homes and delivery trucks were high-profile vehicles. Additionally, most drivers agreed that a sport utility vehicle, pickup truck, and a car were not high-profile vehicles.

DMS Operation Practices

- *DMS operators should use one-frame messages whenever possible, and limit the use of two-frame messages to only those situations where the information cannot be kept to a single frame.* The two-frame message may result in more motorists not remembering some key information from the message. In addition, the majority of the subject drivers preferred the one-frame message to the two-frame message.

- *Single-frame DMS messages should not be flashed in order to try and give them additional attention and target value.* Such practices significantly increase message reading times and do not appear to generate an increased sense of urgency with motorists.

- *DMS operators should not flash one line of a single-frame message in order to increase its target value and attention.* Flashing one line of a single-frame three-unit message on a DMS reduces the ability of motorists to remember parts of the message that are not flashing and increases the reading time of the message.

- *DMS operators should not present redundant information on a two-frame DMS message (i.e., keeping two lines of the message the same and changing the third line).* Total message reading times are significantly increased when redundant information is included.

- *When it is necessary to split a message on a portable DMS, no more than two frames should be used*. Three-frame messages may result in slightly lower comprehension levels for certain units of information. Furthermore, subject drivers strongly preferred the two-frame format above the three-frame format in this study.

- *DMS operators can choose either of two options for displaying a two-frame message on portable DMSs: either displaying each frame for 4 seconds each, or displaying each frame for 2 seconds each.* The first alternative will expose the message once to motorists traveling at 55 mph, whereas the second alternative will expose the message twice (one repetition).

Use of DMSs with Lane Control Signals

- *It is possible to rely on the LCS to indicate which lanes are blocked or closed, and utilize the DMS to provide other key information (what is the problem, how far downstream the problem is located, etc.).* However, redundant information about lane status should be presented on a DMS in conjunction with LCS if no other important information is available to provide motorists. That is, that lane closure information (i.e., "LEFT LANE CLOSED") should be presented in the DMS even when LCS are present rather than simple caution or advisory information (i.e., "EXPECT DELAY" or "USE CAUTION").

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APPENDIX A: LABORATORY INSTRUMENT

Date:_____ **Number_____**
Location:_____ **Group A1**

ANSWER FORM
Session 1

Answers for SIGN 1:
Remember that you are traveling on Interstate 45 towards downtown at **7:30 in the morning during the peak period.**

1. If you saw this message, what would it mean to you?
   Answer: _____
   _____
2. To me, this means I can travel from my current location on the freeway to the downtown exit ramp in (check one of the following):
   ____ less than 20 minutes
   ____ exactly 20 minutes
   ____ about 20 minutes
   ____ more than 20 minutes
   ____ I am unable to determine based on the information given on the sign

After you answer the questions for SIGN 1, press the space bar for SIGN 2.

Answers for SIGN 2:
1. You see this sign message on **Thursday** morning. List the days you think there will be roadwork., starting from the first day that the roadwork will begin. Remember that today is **Thursday**. Please abbreviate the days.
   Answer: _____
   _____

After you answer the question for SIGN 2, press the space bar for SIGN 3.

Answers for SIGN 3:
1. Do you think "Weekend" means roadwork begins Friday evening or Saturday morning?
   (Select one)
   ____ Friday evening
   ____ Saturday morning
2. At approximately what hour does the roadwork begin?
   Answer: _____
3. Do you think "Weekend" means roadwork ends Sunday evening or early Monday?
   (Select one)
   ____ Sunday evening
   ____ Monday morning
4. At approximately what hour does the roadwork end?
   Answer: _____

After you answer the questions for SIGN 3, press the space bar for SIGN 4.

Answers for SIGN 4:

1. During which days of the week do you think the road will be closed? In writing your answer, do not use a dash. Abbreviate **all** days that apply. If you have no idea of the answer, write "I do not know."
   Answer: _____

After you answer the question for SIGN 4, press the space bar for SIGN 5.

Answers for SIGN 5:

1. To me, the term "HIGH PROFILE VEHICLES" means I should slow down if ***(select all that applies)***:
   ____ I am pulling a trailer.
   ____ I am driving a pickup truck.
   ____ I am driving a sport utility vehicle (SUV).
   ____ I am driving a car.
   ____ I am driving a mobile home.
   ____ I am pulling a fifth-wheel mobile home.
   ____ I am driving semi-trailer truck.
   ____ I am driving a delivery truck.
   ____ None of the above

After you answer the question for SIGN 5, press the space bar for SIGN 6

ANSWERS FOR SIGN 6:

1. If you saw this message while traveling on Interstate 45 southbound, what do you think the "10" refers to?
   Answer: _____

After you answer the question of SIGN 6, press the space bar for SIGN 7

ANSWERS FOR SIGN 7:

Remember that you are **traveling on a freeway.**

1. Do these two messages mean the same thing?
   ____ ***yes***
   ____ ***no***
2. If your answer to Number 1 is "no," briefly explain the difference.
   Answer: _____
   _____
   _____
3. What do the messages mean in terms of your driving plans?
   Answer: _____
   _____
   _____

After you answer the questions for SIGN 7, press the space bar for SIGN 8.

Answers for SIGN 8:

1. During which days of the week do you think the road will be closed? In writing your answer, do not use a dash. Abbreviate the days. If you have no idea of the answer, write "I do not know."
   Answer: _____

After you answer the question for SIGN 8, press the space bar for SIGN 9.

Answers for SIGN 9:

Remember that you are traveling on Interstate 45 towards downtown at **7:30 in the morning during the peak period.**

1. If you saw this message, what would it mean to you?
   Answer: _____
   _____
2. To me, this means I can travel from my current location on the freeway to the downtown exit ramp in (check <u>one</u> of the following):
   ____ less than 20 minutes
   ____ exactly 20 minutes
   ____ about 20 minutes
   ____ more than 20 minutes
   ____ I am unable to determine based on the information given on the sign

After you answer the questions for SIGN 9, press the space bar for SIGN 10.

Answers for SIGN 10:
Remember that you are traveling on Interstate 45 towards downtown **during the morning peak period.**

1. To me, this means I will experience a delay of (check **one** of the following):
   ____ 5 minutes or more
   ____ 10 minutes or more
   ____ 15 minutes or more
   ____ 20 minutes or more
   ____ 30 minutes or more
   ____ 1 hour or more
   ____ 2 hours or more
2. To me, this means the speed I will be able to drive will be (check **one** of the following):
   ____ 55 miles per hour and above
   ____ between 45 and 55 miles per hour
   ____ between 35 and 45 miles per hour
   ____ between 25 and 35 miles per hour
   ____ between 15 and 25 miles per hour
   ____ less than 15 miles per hour
3. To me, this means I will have to drive the above selected speed for (check **one** of the following):
   ____ less than 1 mile
   ____ 1 to 2 miles
   ____ 2 to 3 miles
   ____ 3 to 4 miles
   ____ more than 4 miles

After you answer the questions for SIGN 10, press the space bar for SIGN 11.

Answers for SIGN 11:
Remember that you are traveling on Interstate 45 towards downtown **during the morning peak period.**

1. To me, this means I will experience a delay of (check **one** of the following):
   ____ 5 minutes or more
   ____ 10 minutes or more
   ____ 15 minutes or more
   ____ 20 minutes or more
   ____ 30 minutes or more
   ____ 1 hour or more
   ____ 2 hours or more
2. To me, this means the speed I will be able to drive will be (check **one** of the following):
   ____ 55 miles per hour and above
   ____ between 45 and 55 miles per hour
   ____ between 35 and 45 miles per hour
   ____ between 25 and 35 miles per hour
   ____ between 15 and 25 miles per hour
   ____ less than 15 miles per hour
3. To me, this means I will have to drive the above selected speed for (check **one** of the following):
   ____ less than 1 mile
   ____ 1 to 2 miles
   ____ 2 to 3 miles
   ____ 3 to 4 miles
   ____ more than 4 miles
4. In my opinion (**Select One**):
   ____ NORMAL CONGESTION is the same as CONGESTION
   ____ NORMAL CONGESTION is less severe than CONGESTION
   ____ NORMAL CONGESTION is more severe than CONGESTION

After you answer the questions for SIGN 11, press the space bar for SIGN 12.

Answers for SIGN 12:
Remember that you are traveling on Interstate 45 towards downtown **during the morning peak period.**

1. To me, this means I will experience a delay of (check **one** of the following):
   ____ 5 minutes or more
   ____ 10 minutes or more
   ____ 15 minutes or more
   ____ 20 minutes or more
   ____ 30 minutes or more
   ____ 1 hour or more
   ____ 2 hours or more
2. To me, this means the speed I will be able to drive will be (check **one** of the following):
   ____ 55 miles per hour and above
   ____ between 45 and 55 miles per hour
   ____ between 35 and 45 miles per hour
   ____ between 25 and 35 miles per hour
   ____ between 15 and 25 miles per hour
   ____ less than 15 miles per hour
3. To me, this means I will have to drive the above selected speed for (check **one** of the following):
   ____ less than 1 mile
   ____ 1 to 2 miles
   ____ 2 to 3 miles
   ____ 3 to 4 miles
   ____ more than 4 miles
4. In my opinion (**Select One**):
   ____ MINOR CONGESTION is the same as NORMAL CONGESTION
   ____ MINOR CONGESTION is less severe than NORMAL CONGESTION
   ____ MINOR CONGESTION is more severe than NORMAL CONGESTION

After you answer the questions for SIGN 12, press the space bar for SIGN 13.

Answers for SIGN 13:
Remember that you are traveling on Interstate 45 towards downtown **during the morning peak period.**

1. To me, this means I will experience a delay of (check **one** of the following):
   ____ 5 minutes or more
   ____ 10 minutes or more
   ____ 15 minutes or more
   ____ 20 minutes or more
   ____ 30 minutes or more
   ____ 1 hour or more
   ____ 2 hours or more
2. To me, this means the speed I will be able to drive will be (check **one** of the following):
   ____ 55 miles per hour and above
   ____ between 45 and 55 miles per hour
   ____ between 35 and 45 miles per hour
   ____ between 25 and 35 miles per hour
   ____ between 15 and 25 miles per hour
   ____ less than 15 miles per hour
3. To me, this means I will have to drive the above selected speed for (check **one** of the following):
   ____ less than 1 mile
   ____ 1 to 2 miles
   ____ 2 to 3 miles
   ____ 3 to 4 miles
   ____ more than 4 miles
4. In my opinion (**Select One**):
   ____ MAJOR CONGESTION is the same as MINOR CONGESTION
   ____ MAJOR CONGESTION is less severe than MINOR CONGESTION
   ____ MAJOR CONGESTION is more severe than MINOR CONGESTION

After you answer the questions for SIGN 13, press the space bar for SIGN 13.

Answers for SIGN 14:
Remember that you are traveling on Interstate 45 towards downtown **during the morning peak period.**

1. To me, this means I will experience a delay of (check **one** of the following):
   ____ 5 minutes or more
   ____ 10 minutes or more
   ____ 15 minutes or more
   ____ 20 minutes or more
   ____ 30 minutes or more
   ____ 1 hour or more
   ____ 2 hours or more
2. To me, this means the speed I will be able to drive will be (check **one** of the following):
   ____ 55 miles per hour and above
   ____ between 45 and 55 miles per hour
   ____ between 35 and 45 miles per hour
   ____ between 25 and 35 miles per hour
   ____ between 15 and 25 miles per hour
   ____ less than 15 miles per hour
3. To me, this means I will have to drive the above selected speed for (check **one** of the following):
   ____ less than 1 mile
   ____ 1 to 2 miles
   ____ 2 to 3 miles
   ____ 3 to 4 miles
   ____ more than 4 miles
4. In my opinion (**Select One**):
   ____ HEAVY CONGESTION is the same as MAJOR CONGESTION
   ____ HEAVY CONGESTION is less severe than MAJOR CONGESTION
   ____ HEAVY CONGESTION is more severe than MAJOR CONGESTION

After you answer the questions for SIGN 14, press the space bar.

This is the end of the first computer session.

Date:_____ **Number_____**
Location:_____ **Group A1**

ANSWER FORM
Session 2

Answers for sketch:
Remember that you are traveling on a freeway.

1. What is your understanding of the information the red X's and the green arrows give to you?
   Answer: _____
   _____
   _____

3. What driving action would you take if you were driving in the far left lane?
   Answer: _____
   _____
   _____

Answers for SIGN 1:

1. What **new** information does the electronic sign on the screen give to you that you did not get from the information in the sketch?
   Answer: _____
   _____
   _____

2. If you were driving on the highway when you saw the red X's and green arrows and the electronic sign shown on the screen, what other information would you need on the electronic sign to make driving decisions?
   Answer: _____
   _____
   _____

After you answer the questions for Sign 1, press the space bar.

This is the end of Computer Session 2.

Date:_____ **Number_____**
Location:_____ **Group A1**

ANSWER FORM
Session 3

Answers for SIGN 1:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____

After you answer the questions for SIGN 1, press the space bar for SIGN 2.

Answers for SIGN 2:
You are still driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____

After you answer the questions for SIGN 2, press the space bar for SIGN 3.

Answers for SIGN 3:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 3, press the space bar for SIGN 4.

Answers for SIGN 4:

You are driving on southbound Interstate 45.

1. ***Answer:***
2. ***Answer:***
3. ***Answer:***
4. ***Answer:***

After you answer the questions for SIGN 4, press the space bar for SIGN 5.

Answers for SIGN 5:

You are driving on southbound Interstate 45.

1. ***Answer:***
2. ***Answer:***
3. ***Answer:***

After you answer the questions for SIGN 5, press the space bar for SIGN 6.

Answers for SIGN 6:

You are still driving on southbound Interstate 45.

1. ***Answer:***
2. ***Answer:***
3. ***Answer:***

After you answer the questions for SIGN 6, press the space bar for SIGN 7.

Answers for SIGN 7:

You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 7, press the space bar for SIGN 8.

Answers for SIGN 8:

You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 8, press the space bar.

This is the end of Computer Session 3.

Date:_____ **Number_____**
Location:_____ **Group A1**

ANSWER FORM
Session 4

Answers for SIGN 1:
Assume you are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____

After you answer the questions for SIGN 1, press the space bar for SIGN 2.

Answers for SIGN 2:
You are still driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____

After you answer the questions for SIGN 2, press the space bar for SIGN 3.

Answers for SIGN 3:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 3, press the space bar for SIGN 4.

Answers for SIGN 4:

You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 5, press the space bar.

Answers for SIGN 5:

You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions, press the space bar.

This is the end of Computer Session 4.

Date:_____ **Number_____**
Location:_____ **Group A1**

ANSWER FORM
Session 5

Answers for SIGN 1:
Assume you are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 1, press the space bar for SIGN 2.

Answers for SIGN 2:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 2, press the space bar for SIGN 3.

Answers for SIGN 3:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____

After you answer the questions for SIGN 3, press the space bar for SIGN 4.

Answers for SIGN 4:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 4, press the space bar for SIGN 5.

Answers for SIGN 5:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____

After you answer the questions for SIGN 5, press the space bar for SIGN 6.

Answers for SIGN 6:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 6, press the space bar for SIGN 7.

Answers for SIGN 7:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 7, press the space bar for SIGN 8.

Answers for SIGN 8:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 8, press the space bar for SIGN 9.

Answers for SIGN 9:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 9, press the space bar for SIGN 10.

Answers for SIGN 10:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 10, press the space bar for SIGN 11.

Answers for SIGN 11:
You are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 11, press the space bar for SIGN 12.

Answers for SIGN 12:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 12, press the space bar for SIGN 13.

Answers for SIGN 13:

Assume you are driving on southbound Interstate 45.

1. ***Answer:*** _____
2. ***Answer:*** _____
3. ***Answer:*** _____
4. ***Answer:*** _____

After you answer the questions for SIGN 13, press the space bar for SIGN 14.

Answers for SIGN 14:

1. ***Which message do you prefer? Choose only one.***
   ____ The first message style (shown previously).
   ____ The second message style (shown last).

2. Why do you prefer the message style that you selected?
   Answer: _____

After you answer the questions for SIGN 14, press the space bar.

This is the end of Computer Session 5.

Please write any comments in the space below. Then tell the survey administrator that you have finished.

Participant Comments:

APPENDIX B: CITY-BY-CITY STUDY RESULTS

CALENDAR DATES VERSUS DAYS OF THE WEEK FOR COMMUNICATING FUTURE ROADWORK ACTIVITIES

Messages Displayed:

Message with calendar dates	Message with days of the week
ROAD CLOSED JAN 25 – JAN 28	ROAD CLOSED TUES – FRI

Table B-1. During Which Days of the Week Do You Think the Road Is Closed? (Calendar Dates)

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct days of the week	9	17	8	15	15	29	11	21	10	19	53	21
Mon., Tues., Wed., Thurs.	6	12	4	8	7	14	5	10	2	4	24	9
April 18, 19, 20, 21							11	21			11	4
Other Responses	8	15	7	13	10	19	9	17	15	29	49	19
Did not know	29	56	33	64	20	38	16	31	25	48	123	47
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-2. During Which Days of the Week Do You Think the Road Is Closed? (Days of the Week)

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct days of the week	46	88	42	81	44	85	45	86	43	82	220	85
Incorrect days of the week	2	4	5	10	7	13	4	8	4	8	22	8
Tues. & Fri	2	4	5	10			2	4	3	6	12	5
Did not know	2	4			1	2	1	2	2	4	6	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

USE OF THE TERM "FOR 1 WEEK" FOR ROADWORK LASTING SEVEN DAYS

Message Displayed:

ROADWORK
FOR 1 WEEK

Table B-3. List the Days You Think There Will Be Roadwork.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Responses that included Sat. and/or Sun.												
Thurs. – Wed.	14	27	12	23	17	33	17	33	14	27	74	28
Thurs. – Thurs.	12	23	12	23	13	25	10	19	9	17	56	21
Fri- Thurs.	4	8	8	15	1	2	6	12	6	12	25	10
Other	5	10	10	19	10	19	8	15	9	17	42	16
Total with Sat. and Sun.	35	67	42	80	41	79	41	79	38	73	197	76
Responses that did not include Sat. and Sun.												
Thurs. — Wed.	3	6	3	6	1	2			1	2	8	3
Mon. — Fri.	3	6	2	4	5	10	5	9	7	13	22	8
Other Responses	10	19	3	6	5	9	6	12	5	10	29	11
Do not know	1	2	2	4	1	2			1	2	5	2
Total without Sat. and Sun.	17	33	10	20	11	21	11	21	14	27	63	24
TOTALS	52	200	52	100	52	100	52	100	52	100	260	100

USE OF THE SHORTER TERM "WEEKEND" TO DESCRIBE ROADWORK BEGINS ON FRIDAY EVENING AND LASTS UNTIL MONDAY MORNING

Message Displayed:

ROADWAY
NEXT
WEEKEND

Table B-4. When Do You Think Roadwork Will Begin?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Friday evening	17	33	17	33	23	44	20	38	21	40	98	38
Saturday morning	35	67	35	67	29	56	32	62	31	60	162	62
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-5. At Approximately What Hour Does It Begin?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Friday, 5 PM	3	6			3	6	3	6	2	4	11	4
Friday, 6 PM	7	13	4	8	3	6	2	4	6	11	22	8
Friday, 7 PM	1	2	2	4	4	8	4	8			11	4
Friday, 8 PM	2	4	2	4	5	10	1	2	1	2	11	4
Friday, 9 PM	1	2	1	2			3	6	3	6	8	3
Friday, 12 AM Midnight	2	4	9	17	4	8	6	11	11	21	32	12
Saturday, 5 AM	1	2	2	4	1	2	3	6	2	4	9	4
Saturday, 6 AM	8	15	10	19	4	8	9	16	7	13	38	15
Saturday, 7 AM	12	24	7	13	13	25	8	14	7	13	47	18
Saturday, 8 AM	8	15	5	10	6	11	5	10	5	10	31	12
Other responses	7	13	9	17	8	14	6	11	5	10	35	13
No Response			1	2	1	2	3	6	3	6	8	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-6 When Do You Think Roadwork Will End?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sunday evening	42	81	36	70	37	71	27	52	37	71	179	69
Monday morning	10	19	15	30	15	29	24	46	14	27	79	30
No response							1		1	2	2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-7. At Approximately What Hour Does It End?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sunday, 5 PM	9	17	7	13	13	25	4	7	5	10	38	15
Sunday, 6 PM	14	27	7	13	6	11	8	15	7	13	42	16
Sunday, 7 PM	2	4			8	15	3	6	4	7	17	7
Sunday, 8 PM	4	8	4	8			2	4	1	2	11	4
Sunday, 10 PM	3	6	3	6	1	2	2	4	6	12	15	6
Sunday, 12 AM Midnight	5	10	16	31	4	8	10	19	17	34	52	20
Monday, 5 AM			4	8	1	2	13	25	4	8	22	8
Monday, 6 AM	1	2	3	6	4	8	3	6	2	4	13	5
Monday, 8 AM	3	6	1	2	2	4			1	2	7	3
Other responses	11	20	7	13	12	23	6	12	3	6	39	14
No Response					1	2	1	2	2	2	4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

MOTORIST UNDERSTANDING OF TWO ALTERNTIVE TRAVEL TIME MESSAGES

Messages Displayed:

TRAVEL TIME TO DOWNTOWN 20 MINUTES	TRAVEL TIME TO DOWNTOWN AT 7:20 A.M. 20 MINUTES

Table B-8. To Me This Means I Can Travel from My Current Location on the Freeway to the Downtown Exit Ramp In: (Message Without Time-of-Day Shown).

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Exactly 20 minutes	7	13	7	13	5	10	6	11	4	8	29	11
Less than 20 minutes			2	4	3	6					5	2
About 20 minutes	37	71	33	64	41	79	40	77	46	88	197	76
More than 20 minutes	7	14	8	15	2	4	5	10	2	4	24	9
Unable to determine	1	2	2	4	1	2					4	2
Did not respond							1	2			1	0
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-9. To Me This Means I Can Travel from My Current Location on the Freeway to the Downtown Exit Ramp In: (Message With Time-of-Day Shown).

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Exactly 20 minutes	5	10	3	6	6	11	8	15	4	8	26	10
Less than 20 minutes	5	10	6	12	5	10	2	4	1	2	19	7
About 20 minutes	30	57	33	63	31	60	32	62	40	77	166	64
More than 20 minutes	7	13	8	15	7	13	7	13	5	9	34	13
Unable to determine	5	10	2	4	3	6	3	6	2	4	15	6
Did not respond												
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

MOTORISTS' UNDERSTANDING OF THE TERM "EXIT CLOSED" AND "RAMP CLOSED" WHEN REFERRING TO AN EXIT RAMP

Messages Displayed:

EXIT CLOSED	RAMP CLOSED

Table B-10. Do These Two Terms, Ramp and Exit Mean the Same to You?

Responses	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Yes	29	56	34	65	33	64	30	58	27	52	153	59
No	23	44	18	35	19	36	22	42	25	48	107	41
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-11. Drivers Definition of an Exit.

Responses	Dallas	El Paso	Ft Worth	Houston	San Antonio	TOTAL	
	Freq	Freq	Freq	Freq	Freq	Freq	
Exit is used to get off freeway	9	12	15	16	19	71	67
Other Responses	11	5	5	5	5	31	28
Did not know	1					1	1
Did not respond	1	1		1	1	4	4
TOTAL	22	18	20	22	25	107	100

Table B-12. Drivers Definition of a Ramp.

Responses	Dallas	El Paso	Ft Worth	Houston	San Antonio	TOTAL	
	Freq	Freq	Freq	Freq	Freq	Freq	
Ramp is used to get on freeway	7	9	13	8	11	48	45
Freeway to freeway connector	1		1	3	4	9	8
Other Responses	13	7	5	11	10	46	43
Did not know	1					1	1
Did not respond		2		1		3	3
TOTAL	22	18	19	23	25	107	100

Table B-13. What Does This Message Mean in Terms of Your Driving Plans?

Responses	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Go to next exit/ramp	41	78	44	85	45	86	34	65	44	85	208	80
Can not get off or on freeway	2	4			1	2	4	8	1	2	8	2
Other Responses	6	12	6	11	3	6	10	19	5	10	30	13
Did not know	1	2	1	2	3	6	1	2	2	9	8	3
Did not respond	2	4	1	2			3	6			6	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

OMITTING THE ROUTE FROM A MESSAGE

Message displayed:

EXIT
TO I-10
CLOSED

Table B-14. What Does the Number in the Message Refer To?

Responses	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Another highway, Route, Interstate	39	75	38	73	40	77	32	61	46	88	195	75
Exit Number	7	13	13	25	8	15	13	25	4	8	45	17
Other Responses	5	10	1	2	2	4	4	8	2	4	14	6
Did not know	1	2			2	4	3	6			6	2
Did not respond												
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

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MOTORIST INTERPRETATION OF THE WORD "CONGESTION" AND ITS DESCRIPTORS "MAJORS," "HEAVY," MINOR," AND "NORMAL"

Messages Displayed:

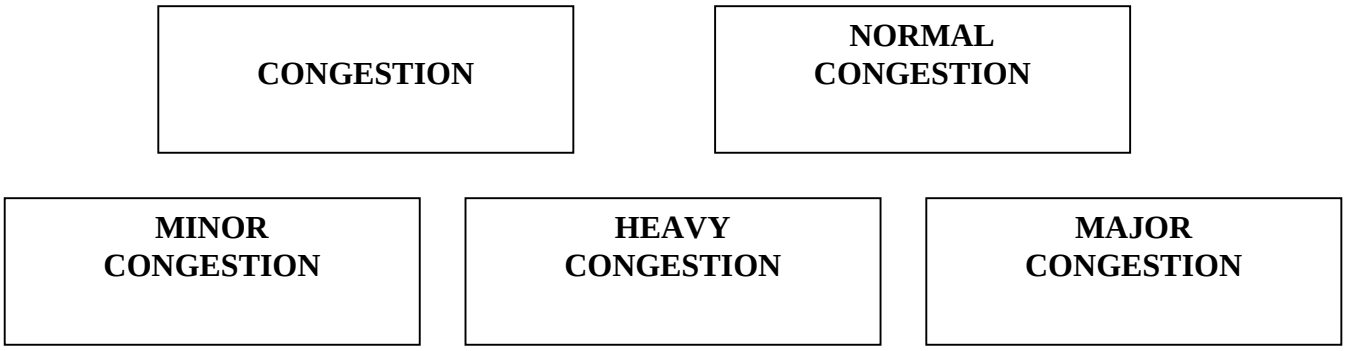


Table B-15. Amount of Delay Implied by Message "CONGESTION."

City	Delay (Freq.)							TOTAL
	5 min or more	10 min or more	15 min or more	20 min or more	30 min or more	50 min or more	120 min or more	
Dallas	9	14	7	10	9	3	0	52
El Paso	11	18	6	7	10	0	0	52
Ft. Worth	11	5	16	5	14	0	1	52
Houston	8	11	8	10	9	3	1	50
San Antonio	9	15	9	15	3	1	0	52
Totals	48	63	46	47	45	7	2	258

Table B-16. Expect Downstream Speeds Implied by Message "CONGESTION."

City	Speeds (Freq.)						TOTAL
	Less than 15 mph	15-25 mph	25-35 mph	35-45 mph	45-55 mph	55 mph and above	
Dallas	7	15	5	8	13	4	52
El Paso	3	6	7	13	15	8	52
Ft. Worth	6	11	10	13	8	4	52
Houston	6	10	10	10	11	3	50
San Antonio	6	13	10	12	8	3	52
Totals	28	55	42	56	55	22	258

Table B-17. Expected Lengths of Congestion Implied by Message "CONGESTION."

City	Lengths (Freq)					TOTAL
	Less than 1 mile	1-2 miles	2-3 miles	3-4 miles	More than 4 miles	
Dallas	6	19	13	3	11	52
El Paso	10	14	13	7	8	52
Ft. Worth	12	11	17	7	5	52
Houston	7	16	10	9	9	51
San Antonio	17	18	11	2	4	52
Totals	52	78	64	28	37	259

Table B-18. Amount of Delay Implied by Message "NORMAL CONGESTION."

City	Delay (Freq.)							TOTAL
	5 min or more	10 min or more	15 min or more	20 min or more	30 min or more	50 min or more	120 min or more	
Dallas	19	11	11	4	5	1	0	51
El Paso	13	15	4	4	7	8	1	52
Ft. Worth	20	14	11	4	3	0	0	52
Houston	21	7	12	7	3	1	1	52
San Antonio	19	14	9	8	2	0	0	52
Totals	92	61	47	27	20	10	2	259

Table B-19. Expect Downstream Speeds Implied by Message "NORMAL CONGESTION."

City	Speeds (Freq.)						TOTAL
	Less than 15 mph	15-25 mph	25-35 mph	35-45 mph	45-55 mph	55 mph and above	
Dallas	1	11	4	15	13	7	51
El Paso	7	9	4	9	12	11	52
Ft. Worth	0	4	9	12	19	8	52
Houston	3	4	7	13	12	13	52
San Antonio	3	7	14	8	12	8	52
Totals	14	35	38	57	68	47	259

Table B-20. Expected Lengths of Congestion Implied by Message "NORMAL CONGESTION."

City	Lengths (Freq)					TOTAL
	Less than 1 mile	1-2 miles	2-3 miles	3-4 miles	More than 4 miles	
Dallas	11	20	7	6	7	51
El Paso	13	11	4	9	15	52
Ft. Worth	17	15	7	6	7	52
Houston	13	16	6	10	7	52
San Antonio	21	13	7	5	6	52
Totals	75	75	31	36	42	259

Table B-21. Amount of Delay Implied by Message "MINOR CONGESTION."

City	Delay (Freq.)							TOTAL
	5 min or more	10 min or more	15 min or more	20 min or more	30 min or more	50 min or more	120 min or more	
Dallas	13	17	13	3	4	1	1	52
El Paso	24	8	14	2	3	1	0	52
Ft. Worth	5	6	10	11	12	2	6	52
Houston	20	14	4	9	3	1	0	51
San Antonio	20	12	14	2	4	0	0	52
Totals	82	57	55	27	26	5	7	259

Table B-22. Expect Downstream Speeds Implied by Message "MINOR CONGESTION."

City	Speeds (Freq.)						TOTAL
	Less than 15 mph	15-25 mph	25-35 mph	35-45 mph	45-55 mph	55 mph and above	
Dallas	0	7	12	15	18	0	52
El Paso	0	5	9	9	20	9	52
Ft. Worth	13	10	17	6	5	1	52
Houston	2	11	10	6	18	5	52
San Antonio	1	9	9	13	15	5	52
Totals	16	42	57	49	76	20	260

Table B-23. Expected Lengths of Congestion Implied by Message "MINOR CONGESTION."

City	Lengths (Freq)					TOTAL
	Less than 1 mile	1-2 miles	2-3 miles	3-4 miles	More than 4 miles	
Dallas	10	21	8	7	6	52
El Paso	18	16	10	6	2	52
Ft. Worth	7	14	17	7	7	52
Houston	10	17	10	9	6	52
San Antonio	23	14	7	5	3	52
Totals	68	82	52	34	24	260

Table B-24. Amount of Delay Implied by Message "HEAVY CONGESTION."

City	Delay (Freq.)							TOTAL
	5 min or more	10 min or more	15 min or more	20 min or more	30 min or more	50 min or more	120 min or more	
Dallas	0	1	2	8	11	22	8	52
El Paso	0	1	7	10	17	13	4	52
Ft. Worth	1	1	2	9	17	17	5	52
Houston	0	1	3	3	15	23	7	52
San Antonio	1	1	7	13	14	12	4	52
Totals	2	5	21	43	74	87	28	260

Table B-25. Expect Downstream Speeds Implied by Message "HEAVY CONGESTION."

City	Speeds (Freq.)						TOTAL
	Less than 15 mph	15-25 mph	25-35 mph	35-45 mph	45-55 mph	55 mph and above	
Dallas	38	5	6	3	0	0	52
El Paso	14	18	10	9	1	0	52
Ft. Worth	22	16	11	2	1	0	52
Houston	32	14	4	1	1	0	52
San Antonio	26	11	7	6	2	0	52
Totals	132	64	38	21	5	0	260

Table B-26. Expected Lengths of Congestion Implied by Message "HEAVY CONGESTION."

City	Lengths (Freq)					TOTAL
	Less than 1 mile	1-2 miles	2-3 miles	3-4 miles	More than 4 miles	
Dallas	2	8	3	11	28	52
El Paso	5	6	10	9	22	52
Ft. Worth	7	6	11	15	13	52
Houston	6	4	3	14	25	52
San Antonio	5	14	9	10	14	52
Totals	25	38	36	59	102	260

Table B-27. Amount of Delay Implied by Message "MAJOR CONGESTION."

City	Delay (Freq.)							TOTAL
	5 min or more	10 min or more	15 min or more	20 min or more	30 min or more	50 min or more	120 min or more	
Dallas	1	3	5	4	19	16	4	52
El Paso	3	6	11	5	14	11	2	52
Ft. Worth	2	0	5	11	22	4	8	52
Houston	3	1	4	5	19	14	6	52
San Antonio	5	2	8	12	12	10	3	52
Totals	14	12	33	37	86	55	23	260

Table B-28. Expect Downstream Speeds Implied by Message "MAJOR CONGESTION."

City	Speeds (Freq.)						TOTAL
	Less than 15 mph	15-25 mph	25-35 mph	35-45 mph	45-55 mph	55 mph and above	
Dallas	16	24	7	5	0	0	52
El Paso	12	16	9	9	6	0	52
Ft. Worth	19	18	9	4	2	0	52
Houston	21	15	9	5	2	0	52
San Antonio	17	14	9	8	4	0	52
Totals	85	87	43	31	14	0	260

Table B-29. Expected Lengths of Congestion Implied by Message "MAJOR CONGESTION."

City	Lengths (Freq)					TOTAL
	Less than 1 mile	1-2 miles	2-3 miles	3-4 miles	More than 4 miles	
Dallas	2	7	9	13	21	52
El Paso	3	10	8	14	17	52
Ft. Worth	5	10	12	12	13	52
Houston	4	3	11	14	19	51
San Antonio	8	15	12	8	9	52
Totals	22	45	52	61	79	259

USE OF THE TERM "HIGH-PROFILE VEHICLES"

Message Displayed

HIGH WINDS
HIGH-PROFILE VEHICLES
REDUCE SPEED

Table B-30. Which of the Following Does the Term "High-Profile Vehicle" Apply To?

Vehicle Type	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Mobile Home	38	73	44	85	41	79	46	88	39	75	208	80
Semi-trailer Truck	42	81	45	87	41	79	46	88	23	44	197	76
Trailer	35	67	36	69	36	69	44	85	34	65	185	71
Fifth-Wheel Mobile Home	40	77	37	71	22	42	45	87	35	67	179	69
Delivery Truck	33	63	31	60	35	67	37	71	30	58	166	64
Sport Utility Vehicle (SUV)	19	37	21	40	23	44	24	46	24	24	111	43
Pickup Truck	10	19	16	31	11	21	15	29	10	19	62	24
Car	5	10	4	8	5	10	4	8	6	12	24	9
None of the above	7	13	3	6	5	10	2	4	9	17	26	10
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

FLASHING AN ENTIRE SINGLE-PANEL MESSAGE

FIXED 8-SECOND MESSAGE STYLE

Flashing Single-Panel Message vs. Non-Flashing Single-Panel (Fixed 8-second) Message

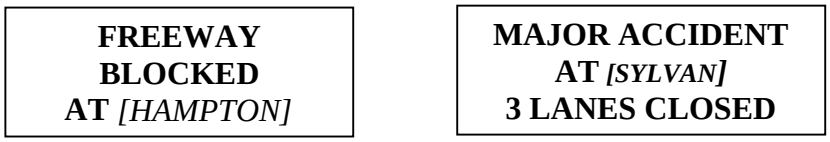


Table B-31. What Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	42	81	52	100	39	75	49	94	50	96	232	89
Other	5	9			7	14	2	4			14	5
Did not remember	5	10			4	7	1	2	2	4	12	5
Did not respond					2	4					2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-32. What Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	46	88	43	83	49	94	44	85	42	81	224	86
Other	4	8	6	12			5	10	8	15	23	9
Did not remember	1	2	3	5	2	4	3	5	2	4	11	4
Did not respond	1	2			1	2					2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-33. Where Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	40	77	46	88	44	85	48	94	52	100	230	88
Other	4	8	2	4	1	2	1	2			8	3
Did not remember	8	15	4	8	4	7	1	2			17	7
Did not respond					3	6	2	4			5	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-34. Where Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	42	81	52	100	46	88	46	88	48	92	234	90
Other	4	8			2	4	4	8	2	4	12	5
Did not remember	5	9			3	6	2	4	2	4	12	4
Did not respond	1	2			1	2					2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-35. What Are You to Do?/What Was Told About the Lanes? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	42	81	44	85	39	74	45	86	44	84	214	82
Other	6	11	8	15	11	22	3	6	5	10	33	13
Did not remember	4	8					4	8	3	6	11	4
Did not respond					2	4					2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-36. What Are You to Do?/What Was Told About the Lanes? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	44	85	47	90	37	71	46	88	44	84	218	84
Other	4	8	3	6	11	21	4	8	5	10	27	10
Did not remember	4	7	1	2	3	6	2	4	2	4	12	5
Did not respond			1	2	1	2			1	2	3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SELF-PACED MESSAGE STYLE

Flashing Single-Panel Message vs. Non-Flashing Single-Panel (Self-Paced) Message

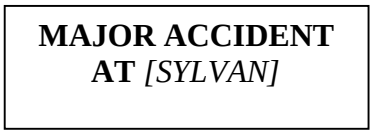


Table B-37. What Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	48	92	37	71	49	94	36	69	39	75	209	80
Other	3	6	8	16	2	4	9	18	7	14	29	11
Did not remember	1	2	7	13	1	2	6	11	6	11	21	8
Did not respond							1	2			1	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-38. What Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	34	65	50	96	23	44	45	86	51	98	203	78
Other	8	16	2	4	23	44	5	10	1	2	39	15
Did not remember	7	13			4	8	2	4			13	5
Did not respond	3	6			2	4					5	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-39. Where Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	47	90	49	94	45	86	44	84	44	84	229	87
Other	1	2	1	2	3	6	5	10	5	10	15	6
Did not remember	3	6	2	4	4	8	2	4	3	6	14	6
Did not respond	1	2					1	2			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-40. Where Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	73	45	86	42	81	46	88	50	96	222	85
Other	3	8	3	6	4	8	5	10			15	6
Did not remember	7	14	4	8	5	9	1	2	2	4	19	7
Did not respond	3	5			1	2					4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-41. What Are You to Do?/What Was Told About the Lanes? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	74	42	80	41	79	38	72	48	92	208	80
Other	7	14	5	10	6	11	9	18	1	2	28	11
Did not remember	4	8	5	10	4	8	3	6	2	4	18	8
Did not respond	2	4			1	2	2	4	1	2	6	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-42. What Are You To Do?/What Was Told About the Lanes? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	45	87	43	82	49	94	43	83	46	88	226	87
Other	1	2	8	16	1	2	8	15	4	8	22	8
Did not remember	4	7	1	2	2	4	1	2	2	4	10	4
Did not respond	2	4									2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-43. Which Message Style Do You Prefer? Flashing Single-Panel Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Flashing single-panel	16	62	11	42	13	50	4	15	13	50	57	44
Non-flashing single-panel	10	38	14	54	13	50	20	77	12	46	69	53
No Preference			1	4			2	8	1	4	4	3
Did not respond												
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Flashing Single-Panel Message Style	Preferred Non-flashing Single-Panel Message Style
• **Easier to read** • **Get your attention** • **Easier to remember** • **Like it flashing** • **Grabs your attention** • **Emphasizes that it is important** • **Gives you a better perspective** • **Alerts you** • **Pay more attention** • **Easier to understand** • **Can see it better** • **Makes you use more caution** • **Clear and precise** • **Not complicated** • **Indicates urgency-not just general information** • **Forces you to read the message over and over**	• **Do not like the sign flashing** • **Easier to read** • **Less distracting** • **Easier to understand** • **Flashing is distracting** • **Easier to remember** • **Stays on longer without flashing** • **Can read it all at once** • **Might miss the message if it is flashing** • **More time to read the message** • **Flashing makes me panic – means trouble** • **Can miss the flashing sign if you are driving fast** • **Flashing makes me tense**

Table B-44. Which Message Style Do You Prefer?
Non-Flashing Single-Panel Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Flashing single-panel	17	65	12	46	13	50	16	62	11	42	69	53
Non-flashing single-panel	6	23	11	42	12	46	9	34	14	54	52	40
No Preference	2	8	3	12	1	4	1	4			7	5
Did not respond	1	4							1	4	2	2
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Flashing Single-Panel Message Style	Preferred Non-flashing Single-Panel Message Style
• **It repeats itself** • **Gets your attention** • **Direct and to the point** • **Alerts you** • **Is better** • **Makes the incident seem more recent** • **Keeps you focused on the problem** • **Easier to remember** • **Flashes quickly so you can see it all** • **Gives you more information** • **If I blink I can still catch the message** • **Gave the entire message** • **Makes it safer**	• **Had more time to read and understand** • **Do not like flashing messages** • **One simple message displayed** • **Flashing is distracting** • **It is not flashing** • **Whole message together** • **Can see it all at the same time** • **Gives you more time to read & absorb it** • **Clear and precise** • **All on one sign** • **Easier to understand** • **Gives all the information together** • **Flashing is confusing-have to start over each time**

FLASHING ONE LINE OF A SINGLE-PANEL MESSAGE

FIXED 8-SECOND MESSAGE STYLE

Flashing Top Line of a One-Frame Message vs. Non-Flashing One-Frame Message (Fixed 8-second)

FREEWAY CLOSED **AT [BECKLEY AVE]** **FOLLOW DETOUR**	**TRUCK ACCIDENT** **AT [FERGUSON RD]** **USE SERVICE ROAD**

Table B-45. What Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	44	84	36	69	45	86	42	81	36	69	203	78
Other	3	6	10	19	3	6	7	13	8	16	31	12
Did not remember	3	6	6	12	4	8	3	6	8	15	24	9
Did not respond	2	4									2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-46. What Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	38	73	50	96	27	52	48	92	46	88	209	80
Other	9	17	1	2	20	38	3	6	3	6	36	14
Did not remember	5	10	1	2	4	8	1	2	3	6	14	5
Did not respond					1	2					1	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-47. Where Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	43	83	50	96	46	88	48	92	44	85	231	89
Other	4	8	1	2	5	10	3	6	2	4	15	6
Did not remember	5	9	1	2	1	2	1	2	5	9	13	5
Did not respond									1	2	1	0
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-48. Where Is the traffic problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	50	96	49	94	42	80	49	94	48	92	238	92
Other	1	2	3	6	7	14	2	4	3	6	16	6
Did not remember					3	6	1	2	1	2	5	2
Did not respond	1	2									1	0
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-49. What Are You to Do? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	26	50	38	72	26	50	35	67	34	66	159	61
Other	15	29	11	21	20	38	10	19	9	17	65	25
Did not remember	7	13	3	6	6	12	4	8	9	17	29	11
Did not respond	4	8					3	6			7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-50. What Are You To Do? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	41	78	37	71	38	73	42	81	34	65	192	74
Other	3	6	14	27	8	15	8	15	10	19	43	16
Did not remember	6	12	1	2	4	8			4	8	15	6
Did not respond	2	4			2	4	2	4	4	8	10	4
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SELF-PACED MESSAGE STYLE

Flashing Top Line of a One-Frame Message vs. Non-Flashing One-Frame Message (Self-paced)

FREEWAY CLOSED AT [BECKLEY AVE] FOLLOW DETOUR	**TRUCK ACCIDENT AT [FERGUSON RD] USE SERVICE ROAD**

Table B-51. What Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	36	69	47	90	25	48	44	84	46	88	198	76
Other	9	17	2	4	20	39	5	10	3	6	39	15
Did not remember	5	10	3	6	7	13	2	4	3	6	20	8
Did not respond	2	4					1	2			3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-52. What Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	45	86	32	62	44	84	31	60	41	79	193	74
Other	4	8	13	25	5	10	14	27	8	15	44	17
Did not remember	2	4	7	13	2	4	7	13	3	6	21	8
Did not respond	1	2			1	2					2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-53. Where Is the Traffic Problem? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	48	92	49	94	48	92	48	92	51	98	244	94
Other	2	4			2	4	3	6	1	2	8	3
Did not remember	1	2	2	4	2	4	1	2			6	2
Did not respond	1	2	1	2							2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-54. Where Is the Traffic Problem? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	50	96	47	90	46	88	45	86	49	94	237	91
Other	1	2	3	6	2	4	1	2	1	2	8	3
Did not remember	1	2	2	4	4	8	4	8	2	4	13	5
Did not respond							2	4			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-55. What Are You to Do? Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	74	31	59	30	57	28	54	29	56	157	60
Other	5	10	16	31	18	35	17	33	17	33	73	28
Did not remember	7	14	5	10	3	6	5	9	6	11	26	10
Did not respond	1	2			1	2	2	4			4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-56. What Are You to Do? Non-Flashing Single-Panel Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	35	68	34	66	35	67	37	71	44	84	185	71
Other	9	17	10	19	14	27	10	19	4	8	47	18
Did not remember	7	13	8	15	3	6	4	8	4	8	26	10
Did not respond	1	2					1	2			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SUBJECT DRIVERS PREFERENCES

Table B-57. Which Message Style Do You Prefer? Flashing One Line Of A One-Frame Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Flashing single-panel	13	50	7	27	11	42	13	50	13	50	57	44
Non-flashing single-panel	13	50	18	69	15	58	12	46	13	50	71	55
No Preference			1	4			1	4			2	1
Did not respond												
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Top-Line Flashing Single-Panel Message Style	Preferred Non-flashing Single-Panel Message Style
• **Gets your attention** • **Gets the point across** • **Easier to read** • **Clear and precise** • **Highlights the important feature** • **Because it is flashing** • **Emphasizes what is important** • **Alerts you** • **Easier to remember** • **Flashing alerts you** • **Likes the bottom part stay the same and top gets your attention** • **Easier to understand** • **Flashing is better** • **Flashing alerts you to what is wrong**	• **Flashing is distracting** • **Clear and precise** • **Easier to read** • **Can miss the message if it flashes** • **Have more time to read** • **Do not like it flashing** • **Easier to understand** • **Flashing is confusing** • **Flashing is difficult to remember** • **Only remember the part that is flashing** • **Didn't have to pay attention to the flashing** • **Got to the point quicker** • **Message stays on the screen longer** • **Message all together** • **Easier to remember** • **Flashing can draw attention away from rest of message** • **Information about accident is not as important as what I need to do**

Table B-58. Which Message Style Do You Prefer? Non-Flashing One Line of a One-Frame Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Flashing single-panel	17	65	13	50	17	65	16	62	19	73	82	63
Non-flashing single-panel	8	31	12	46	8	31	10	38	6	23	44	34
No Preference			1	4	1	4			1	4	3	2
Did not respond	1	4									1	1
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

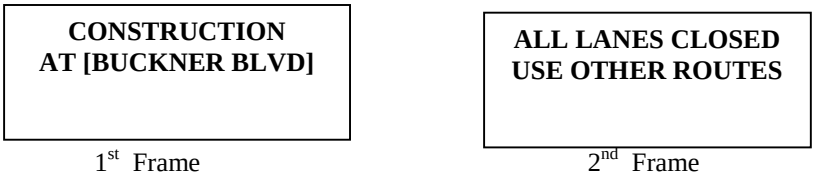
Typical comments:

Preferred Top-Line Flashing Single-Panel Message Style	Preferred Non-flashing Single-Panel Message Style
• **Makes me read it twice** • **Gets your attention** • **Emphasizes what is important** • **Easier to read** • **Clear and precise** • **Because it is flashing** • **Warning of accident not just construction** • **Alerts you** • **Easier to understand** • **Lets me know what the problem is** • **Easier to read** • **Keeps you focused on problem** • **Informs you on what happened** • **Easier to remember** • **It stresses the major problem for those who speed** • **Highlights what is happening**	• **Easier to read** • **Flashing is distracting** • **Message is consistent** • **Do like the flashing** • **Easier to remember** • **One simple message** • **Have more time to read** • **Clear and precise** • **Flashing is confusing** • **Flashing part doesn't tell you what to do** • **Easier to understand and read** • **Only remember the part that is flashing** • **Like it on one sign** • **Do not like the flashing** • **Instructions more important than problem** • **Less distracting** • **Flashing one line is obnoxious** • **Flashing is disturbing to the eyes** • **Do not care what the problem is**

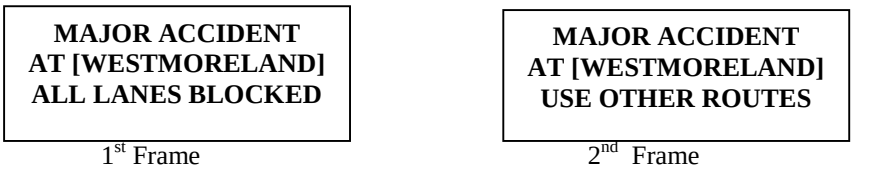
REDUNDANCY IN A TWO-FRAME MESSAGE

FIXED 8-SECOND MESSAGE STYLE

or



AND



or

Table B-59. How Many Lanes Are Blocked? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	38	73	48	92	41	79	44	84	42	81	213	82
Other	7	13	1	2	6	12	2	4	7	13	23	9
Did not remember	5	10	3	6	4	7	4	8	3	6	19	7
Did not respond	2	4			1	2	2	4			5	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-60. How Many Lanes Are Blocked? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	46	88	48	92	44	85	49	94	46	88	233	89
Other	2	4	4	8	5	9	2	4	2	4	15	6
Did not remember	4	8			2	4	1	2	3	6	10	4
Did not respond					1	2			1	2	2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-61. What Is the Traffic Problem? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	36	69	43	82	45	86	41	79	46	89	211	81
Other	10	19	8	16	6	12	7	13	5	9	36	14
Did not remember	5	10	1	2	1	2	4	8	1	2	12	4
Did not respond	1	2									1	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-62. What Is the Traffic Problem? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	36	69	44	85	38	73	47	90	36	69	201	77
Other	13	25	6	11	10	19	2	4	13	25	44	17
Did not remember	3	6	2	4	4	8	1	2	3	6	13	5
Did not respond							2	4			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-63. What Are You Told to Do? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	29	56	38	73	38	73	33	64	30	58	168	65
Other	12	23	7	13	11	21	11	21	12	23	53	20
Did not remember	6	11	5	10	2	4	7	13	10	19	30	12
Did not respond	5	10	2	4	1	2	1	2			9	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-64. What Are You Told to Do? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	32	62	39	75	31	60	37	71	37	71	176	67
Other	13	25	10	19	10	19	11	21	6	12	50	19
Did not remember	7	13	3	6	10	19	4	8	9	17	33	13
Did not respond					1	2					1	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-65. Where Is the Traffic Problem Located? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	41	79	40	77	26	50	41	79	40	77	188	72
Other	2	4	7	13	18	35	5	10	2	4	34	13
Did not remember	7	13	4	8	7	13	5	9	8	15	31	12
Did not respond	2	4	1	2	1	2	1	2	2	4	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-66. Where Is the Traffic Problem Located? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	46	88	46	88	43	83	39	75	41	79	215	82
Other	1	2	3	6	2	4	3	6	4	8	13	5
Did not remember	4	8	2	4	7	13	6	11	6	11	25	10
Did not respond	1	2	1	2			4	8	1	2	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SELF-PACED MESSAGE STYLE

Table B-67. How Many Lanes Are Blocked? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	48	92	47	90	46	88	46	88	46	88	233	90
Other	1	2	4	8	4	8	5	10	4	8	18	7
Did not remember	2	4	1	2	2	4	1	2	2	4	8	3
Did not respond	1	2									1	0
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-68. How Many Lanes Are Blocked? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	49	94	46	88	42	81	49	94	50	96	236	91
Other	2	4	4	8	6	11	3	6	1	2	16	6
Did not remember			1	2	3	6			1	2	5	2
Did not respond	1	2	1	2	1	2					3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-69. What Is the Traffic Problem? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	41	79	49	94	38	73	41	79	43	83	212	81
Other	8	15	3	6	9	17	5	9	6	11	31	12
Did not remember	3	6			5	10	4	8	3	6	15	6
Did not respond							2	4			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-70. What Is the Traffic Problem? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	47	90	43	82	43	83	34	65	44	84	211	81
Other	3	6	5	10	7	13	14	27	8	16	37	14
Did not remember	1	2	3	6	2	4	4	8			10	4
Did not respond	1	2	1	2							2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-71. What Are You Told to Do? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	75	28	54	35	67	37	71	45	86	184	71
Other	4	8	18	35	16	31	9	17	4	8	51	19
Did not remember	6	11	6	11	1	2	4	8	3	6	20	8
Did not respond	3	6					2	4			5	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-72. What Are You Told to Do? Same Information with Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	75	36	69	36	69	36	69	41	79	188	72
Other	4	8	9	18	12	23	10	19	6	12	41	16
Did not remember	8	15	7	13	3	6	5	10	4	7	27	10
Did not respond	1	2			1	2	1	2	1	2	4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-73. Where Is the Traffic Problem Located? Keeping Top Two Lines of a Two-Frame Message the Same While Changing the Last Line on Each Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	43	83	45	87	42	81	35	67	48	92	213	82
Other	5	9	1	2	3	6	6	12	3	6	18	7
Did not remember	2	4	6	11	7	13	11	21			26	10
Did not respond	2	4							1	2	3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-74. Where is the Traffic Problem Located? Same Information with

Redundancy Removed.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	41	79	41	79	27	52	36	69	44	84	189	73
Other	6	11	6	11	18	35	7	14	3	6	40	15
Did not remember	4	8	5	10	6	11	8	15	4	8	27	10
Did not respond	1	2			1	2	1	2	1	2	4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SUBJECT DRIVERS' PREFERENCES

Table B-75. Which Message Style Do You Prefer? Flashing One Line of a One-Frame Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Flashing single-panel	13	50	7	27	11	42	13	50	13	50	57	44
Non-flashing single-panel	13	50	18	69	15	58	12	46	13	50	71	55
No Preference			1	4			1	4			2	1
Did not respond												
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Top-Line Flashing Single-Panel Message Style	Preferred Non-flashing Single-Panel Message Style
• **Gets your attention** • **Gets the point across** • **Easier to read** • **Clear and precise** • **Highlights the important feature** • **Because it is flashing** • **Emphasizes what is important** • **Alerts you** • **Easier to remember** • **Flashing alerts you** • **Likes the bottom part stay the same and top gets your attention** • **Easier to understand** • **Flashing is better** • **Flashing alerts you to what is wrong**	• **Flashing is distracting** • **Clear and precise** • **Easier to read** • **Can miss the message if it flashes** • **Have more time to read** • **Do not like it flashing** • **Easier to understand** • **Flashing is confusing** • **Flashing is difficult to remember** • **Only remember the part that is flashing** • **Didn't have to pay attention to the flashing** • **Got to the point quicker** • **Message stays on the screen longer** • **Message all together** • **Easier to remember** • **Flashing can draw attention away from rest of message** • **Information about accident is not as important as what I need to do**

Non-Flashing one line of a one-frame message shown first

Table B-76. Which Message Style Do You Prefer?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Flashing single-panel	17	65	13	50	17	65	16	62	19	73	82	63
Non-flashing single-panel	8	31	12	46	8	31	10	38	6	23	44	34
No Preference			1	4	1	4			1	4	3	2
Did not respond	1	4									1	1
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Top-Line Flashing Single-Panel Message Style	Preferred Non-flashing Single-Panel Message Style
• **Makes me read it twice** • **Gets your attention** • **Emphasizes what is important** • **Easier to read** • **Clear and precise** • **Because it is flashing** • **Warning of accident not just construction** • **Alerts you** • **Easier to understand** • **Lets me know what the problem is** • **Easier to read** • **Keeps you focused on problem** • **Informs you on what happened** • **Easier to remember** • **It stresses the major problem for those who speed** • **Highlights what is happening**	• **Easier to read** • **Flashing is distracting** • **Message is consistent** • **Do like the flashing** • **Easier to remember** • **One simple message** • **Have more time to read** • **Clear and precise** • **Flashing is confusing** • **Flashing part doesn't tell you what to do** • **Easier to understand and read** • **Only remember the part that is flashing** • **Like it on one sign** • **Do not like the flashing** • **Instructions more important than problem** • **Less distracting** • **Flashing one line is obnoxious** • **Flashing is disturbing to the eyes** • **Do not care what the problem is**

THREE-FRAME MESSAGES ON A PORTABLE DMS

FIXED 8-SECOND MESSAGE STYLE

Two-frame messages vs. Three-frame messages (Fixed 8-second)

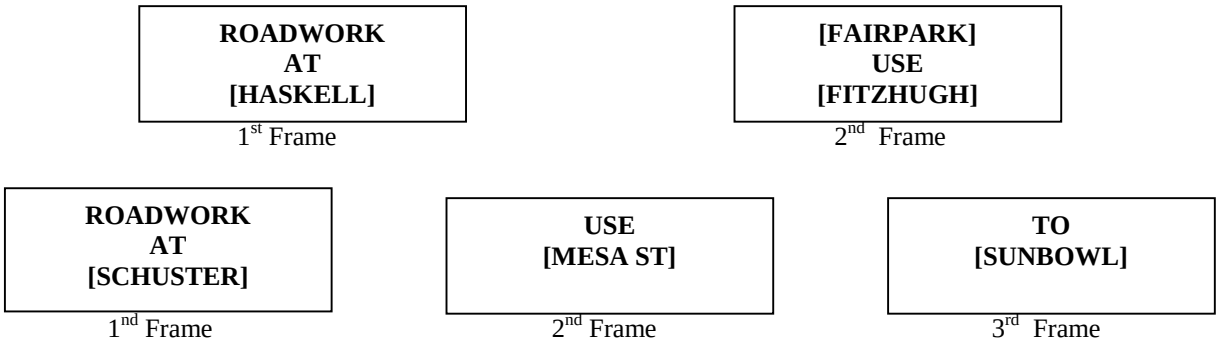


Table B-77. What Is the Traffic Problem? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	21	40	25	48	16	31	31	60	27	52	120	46
Other	21	40	15	29	23	44	14	27	14	27	87	33
Did not remember	7	14	11	21	13	25	6	11	9	17	46	18
Did not respond	3	6	1	2			1	2	2	4	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-78. What Is the Traffic Problem? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	31	60	17	33	28	54	19	36	7	14	102	39
Other	12	23	27	52	13	25	24	46	24	46	100	39
Did not remember	8	15	7	13	8	15	8	16	21	40	52	20
Did not respond	1	2	1	2	3	6	1	2			6	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-79. What Should Drivers Do Who Are Going to the Destination? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	34	65	45	86	32	62	35	67	31	60	177	68
Other	12	23	4	8	15	29	12	23	13	25	56	22
Did not remember	4	8	3	6	5	9	2	4	8	15	22	8
Did not respond	2	4					3	6			5	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-80. What Should Drivers Do Who Are Going to the Destination? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	32	62	41	79	31	60	36	69	30	58	170	65
Other	11	21	7	14	12	23	9	18	12	23	51	20
Did not remember	8	15	4	7	8	15	7	13	9	17	36	14
Did not respond	1	2			1	2			1	2	3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-81. Where Is the Traffic Problem Located? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	31	60	47	90	46	88	45	86	37	71	206	79
Other	9	17			4	8	3	6	6	12	22	8
Did not remember	9	17	4	8	2	4	3	6	7	13	25	10
Did not respond	3	6	1	2			1	2	2	4	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-82. Where Is the Traffic Problem Located? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	31	60	36	69	42	80	37	71	29	56	175	67
Other	7	13	9	17	4	8	7	14	8	15	35	14
Did not remember	10	19	6	12	3	6	7	13	14	27	40	15
Did not respond	4	8	1	2	3	6	1	2	1	2	10	4
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-83. What Destination Is on the Sign? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	33	63	41	79	44	85	43	83	26	50	187	72
Other	14	27	6	11	6	11	8	15	16	31	50	19
Did not remember	5	10	5	10	2	4	1	2	7	13	20	8
Did not respond									3	6	3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-84. What Destination Is on the Sign? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	28	54	38	73	42	81	40	77	33	64	181	70
Other	14	27	12	23	7	13	7	13	9	17	49	19
Did not remember	8	15	2	4	1	2	3	6	9	17	23	9
Did not respond	2	4			2	4	2	4	1	2	7	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SELF-PACED MESSAGE STYLE

Table B-85. What Is the Traffic Problem? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	31	60	17	33	22	42	13	25	12	23	95	36
Other	14	26	24	46	15	29	29	56	29	56	111	43
Did not remember	6	12	11	21	14	27	9	17	11	21	51	20
Did not respond	1	2			1	2	1	2			3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-86. What Is the Traffic Problem? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	20	39	21	40	9	17	31	60	25	48	106	41
Other	20	39	17	33	30	58	14	27	15	29	96	37
Did not remember	10	18	12	23	12	23	6	11	10	19	50	19
Did not respond	2	4	2	4	1	2	1	2	2	4	8	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-87. What Should Drivers Do Who Are Going to the Destination? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	75	38	73	27	52	30	58	34	65	168	65
Other	8	15	9	18	10	19	15	28	13	25	55	21
Did not remember	5	10	5	9	14	27	6	12	5	10	35	13
Did not respond					1	2	1	2			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-88. What Should Drivers Do Who Are Going to the Destination? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	44	84	44	84	30	58	30	57	43	83	191	73
Other	4	8	6	12	14	27	15	29	6	11	45	17
Did not remember	3	6	2	4	7	13	3	6	2	4	17	7
Did not respond	1	2			1	2	4	8	1	2	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-89. Where Is The Traffic Problem Located? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	40	77	40	77	40	77	39	75	45	88	204	78
Other	7	13	5	10	7	13	7	13	5	10	31	12
Did not remember	4	8	6	11	5	10	4	8	2	4	21	8
Did not respond	1	2	1	2			2	4			4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-90. Where Is the Traffic Problem Located? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	35	67	42	80	34	65	41	79	37	71	189	73
Other	4	8	5	10	10	19	4	8	6	12	29	11
Did not remember	11	21	3	6	7	14	5	9	8	15	34	13
Did not respond	2	4	2	4	1	2	2	4	1	2	8	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-91. What Destination Is on the Sign? Two-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	38	73	29	56	33	63	33	63	40	77	173	67
Other	8	15	12	23	15	29	14	27	9	17	58	22
Did not remember	5	10	9	17	3	6	3	6	2	4	22	8
Did not respond	1	2	2	4	1	2	2	4	1	2	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Table B-92. What Destination Is on the Sign? Three-Frame Message.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	41	79	32	61	39	75	36	69	41	78	189	73
Other	6	11	14	27	13	25	12	23	8	16	53	20
Did not remember	4	8	5	10			4	8	3	6	16	6
Did not respond	1	2	1	2							2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SUBJECT DRIVERS' PREFERENCES

Table B-93. Which Message Style Do You Prefer? Two-Frame Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Two-frame message	22	85	15	58	22	85	15	58	12	46	86	66
Three-frame message	3	11	11	42	4	15	10	38	14	54	42	32
No Preference												
Did not respond	1	4					1	4			2	2
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Two-Frame Message Style	Preferred Three-Frame Message Style
• **Easier to remember** • **By the time you get to the 3rd sign, I had forgotten the first two** • **Too fast with three parts** • **Easier to read** • **Not as long and confusing as the other** • **Can read the two-part message faster** • **It's shorter** • **Clear and precise** • **Prefer two over three** • **Three parts is too much information to remember** • **Three take too long to read** • **Easier to understand** • **It's all at once** • **Do not have to wait for the last message** • **Gives you more time to watch the road** • **Would pass the sign before I would have time to read all three** • **Less to read** • **Easier to see** • **Everything together** • **Three is too many signs** • **Makes better sense**	• **Clear and precise** • **Easier to comprehend** • **Easier to remember** • **Clear and precise** • **Gives equal information on each sign** • **Easier to understand** • **Information separated and gave better directions** • **Breaks up information** • **Easier to understand** • **Do not have as much to remember on each sign** • **Move informative** • **Explains in detail** • **Gives you more opportunity to read the sign** • **Not as much to remember all at once**

Table B-94. Which Message Style Do You Prefer? Three-Frame Message Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Two-frame message	12	46	21	80	20	77	20	77	21	81	94	72
Three-frame message	11	42	3	12	3	12	5	19	5	19	27	21
No Preference	1	4			3	11					4	3
Did not respond	2	8	2	8			1	4			5	4
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Two-Frame Message Style	Preferred Three-Frame Message Style
• More time to read signs • More complete message • Easier to understand • Easier to remember • Easier to remember • Clear and precise • Too long to remember what was on first sign • Three frames is too much information • Three signs is too long and confusing • Less time and attention from driving • Message display shorter • More information in less time • Less complicated • Not flashing as fast • Information all together • Other takes too much time to read • Longer viewing time • Less distracting • The fewer the signs, the better I understand • More time to read the sign • Easier to process the information	• Clear and precise • Terminology on other message is confusing • Easier to assimilate • Easier to comprehend • Easier to read • Have more time to read • Did not understand other message • Too much information on other signs • Other sign was confusing • Stated better • Simple and easy to understand • More time to absorb it • Makes more sense • Not as much information all at once • Other is too crammed

REPEAT THE DISPLAY OF A TWO-FRAME MESSAGE ON PORTABLE DMSs

Messages Displayed:

FREEWAY BLOCKED AT [MOTLEY]	DOWNTOWN USE US-80
1st Frame	2nd Frame

or

ROADWORK AT COLLINS	[FORT WORTH] USE I-20

Table B-95. What Is the Traffic Problem? Message with No Repetition – Each Frame Displayed 4 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	34	66	37	71	31	60	44	84	32	62	178	68
Other	11	21	6	12	15	29	4	8	16	30	52	20
Did not remember	6	11	9	17	6	11	3	6	4	8	28	11
Did not respond	1	2					1	2			2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-96. What Is the Traffic Problem? Message with One Repetition – Each Frame Displayed 2 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	34	65	28	54	35	50	37	71	31	60	165	64
Other	9	18	10	19	9	34	8	16	16	30	52	20
Did not remember	6	11	12	23	8	16	5	9	4	8	35	13
Did not respond	3	6	2	4			2	4	1	2	8	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-97. Where Is the Traffic Problem Located? Message with No Repetition - Each Frame Displayed 4 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	45	86	39	75	37	71	49	94	44	84	214	82
Other	3	6	2	4	11	21	1	2	4	8	21	8
Did not remember	3	6	10	19	4	8	2	4	3	6	22	9
Did not respond	1	2	1	2					1	2	3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-98. Where Is the Traffic Problem Located? Message with One Repetition – Each Frame Displayed 2 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	44	85	39	75	36	69	37	71	48	92	204	78
Other	3	6	3	6	9	17	10	19	1	2	26	10
Did not remember	2	4	6	11	7	14	3	6	2	4	20	8
Did not respond	3	5	4	8			2	4	1	2	10	4
TOTAL	52	100	52	100	52	100	52	100	52	100	260	4

✔ **Correct answer**

Table B-99. What Destination Is on the Sign? Message with No Repetition – Each Frame Displayed 4 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	31	60	28	54	20	38	27	52	18	34	124	48
Other	10	19	7	13	14	27	7	13	16	31	54	21
Did not remember	8	15	16	31	17	33	15	29	17	33	73	28
Did not respond	3	6	1	2	1	2	3	6	1	2	9	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-100. What Destination Is on the Sign? Message with One Repetition – Each Frame Displayed 2 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	23	44	37	71	26	50	37	71	25	48	148	57
Other	13	25	4	8	12	23	6	12	9	17	44	17
Did not remember	11	21	9	17	14	27	5	9	17	33	56	21
Did not respond	5	10	2	4			4	8	1	2	12	5
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-101. What Should Drivers Do Who Are Going to the Destination? Message with No Repetition - Each Frame Displayed 4 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	29	56	35	67	28	54	36	69	31	59	159	61
Other	16	31	1	2	16	30	5	10	9	18	47	18
Did not remember	6	11	14	27	8	16	8	15	11	21	47	18
Did not respond	1	2	2	4			3	6	1	2	7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-102. What Should Drivers Do Who Are Going to the Destination? Message with One Repetition – Each Frame Displayed 2 Seconds.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	30	57	30	58	31	60	19	36	21	42	131	51
Other	13	26	9	17	11	21	16	31	14	26	63	24
Did not remember	7	13	11	21	9	17	12	23	16	31	55	21
Did not respond	2	4	2	4	1	2	5	10	1	2	11	4
TOTAL	52	100	32	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

SUBJECT DRIVERS' PREFERENCES

Table B-103. Which Message Style Do You Prefer? Message with No Repetition Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Single display	13	50	11	42	7	27	13	50	6	23	50	38
Repeat display	10	38	15	58	15	58	9	34	19	73	68	52
No Preference	3	12			4	15	2	8	2	4	11	8
Did not respond							2	8			2	2
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Table B-104. Which Message Style Do You Prefer? Message with Repetition Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Single display	9	35	12	46	17	65	14	54	15	58	67	52
Repeat display	11	42	8	31	7	27	9	35	8	31	43	33
No Preference	6	23	6	23	2	8	3	11	3	11	20	15
Did not respond												
TOTAL	26	100	26	100	26	100	26	100	26	100	130	100

Explain why

Typical comments:

Preferred Single Display Message Style	Preferred Repeat Display Message Style
• **Easier to read** • **Easier to comprehend** • **Clear and precise** • **Easier to understand** • **Easier to remember** • **Other message style moves too quickly** • **Slower, better chance of reading it** • **Other message was too fast** • **More time to read it** • **Made more sense** • **Flashing is distracting** • **Would be long gone by the time it came around again** • **Repeats the information** • **Uninterrupted by flashing** • **Seemed shorter** • **Confusing when it flashes**	• **Repeats and gives you more time to comprehend** • **Easier to read** • **Easier to see** • **Easier to remember** • **Clearer** • **Gives you more chances to read it** • **Gives you the information at a faster rate** • **If you miss the first time, you can get it on the second flash** • **If driving fast, gives you an opportunity to see the entire message faster** • **Information faster** • **Gets your attention**

REPEAT THE DISPLAY OF A TWO-FRAME MESSAGE ON PORTABLE DMSs

Four units of information on one frame

Dallas

ACCIDENT
AT COLISEUM
2 LANES CLOSED
USE LOOP 410

El Paso

ACCIDENTAT
SHEPHERD
2 LANES CLOSED
USE HARDY TOLL RD

Fort Worth

ACCIDENT
AT VICTORY
2 LANES CLOSED
USE US-287

Houston

ACCIDENT
AT LEE TREVINO
2 LANES CLOSED
USE LOOP 375

San Antonio

ACCIDENT
AT ROYAL LANE
2 LANES CLOSED
USE NORTH TOLLWAY

Four units of information on two frames

Dallas

ACCIDENT
AT ROYAL LANE

1st Frame

2 LANES CLOSED
USE NORTH TOLLWAY

2nd Frame

El Paso

ACCIDENT
AT SHEPHERD

1st Frame

2 LANES CLOSED
USE HARDY TOLL RD

2nd Frame

Fort Worth

ACCIDENT
AT VICTORY

1st Frame

2 LANES CLOSED
USE US-287

2nd Frame

Houston

ACCIDENT
AT LEE TREVINO

1st Frame

2 LANES CLOSED
USE LOOP 375

2nd Frame

San Antonio

ACCIDENT
AT ROYAL LANE

1st Frame

2 LANES CLOSED
USE NORTH TOLLWAY

2nd Frame

Table B-105. What Is the Traffic Problem? Four Units of Information on One Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	48	92	46	88	48	92	51	98	47	90	240	92
Other	4	8	4	8	2	4	1	2	5	10	16	6
Did not remember			2	4	2	4					4	2
Did not respond												
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-106. What Is the Traffic Problem? Four Units of Information on Two Frames.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	49	94	47	90	43	83	45	86	48	92	232	90
Other	3	6	5	10	7	13	4	8	2	4	21	8
Did not remember					2	4	3	6	1	2	6	2
Did not respond									1	2	1	0
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-107. Where Is the Traffic Problem? Four Units of Information on One Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	48	92	45	86	37	71	41	79	44	84	215	83
Other	2	4	5	10	10	19	2	4	2	4	21	8
Did not remember	2	4	1	2	5	10	7	13	5	10	20	8
Did not respond			1	2			2	4	1	2	4	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-108. Where Is the Traffic Problem? Four Units of Information on Two Frames.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	47	90	45	86	42	81	42	81	45	86	221	85
Other	1	2	2	4	2	4	4	8	2	4	11	4
Did not remember	2	4	2	4	6	11	6	11	4	8	20	8
Did not respond	2	4	3	6	2	4			1	2	8	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ *Correct answer*

Table B-109. How Many Lanes Are Closed? Four Units of Information on One Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	39	75	36	69	41	79	43	83	47	90	206	79
Other	6	12	12	23	6	11	4	8	2	4	30	12
Did not remember	6	11	3	6	4	8	5	9	3	6	21	8
Did not respond	1	2	1	2	1	2					3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-110. How Many Lanes Are Closed? Four Units of Information on Two Frames.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	37	71	32	62	33	63	39	75	41	79	182	70
Other	6	12	12	23	13	25	7	13	3	6	41	16
Did not remember	8	15	6	11	5	10	6	12	7	13	32	12
Did not respond	1	2	2	4	1	2			1	2	5	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-111. What Should You Do? Four Units of Information on One Frame.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	32	61	34	65	29	56	36	69	33	63	164	63
Other	11	22	10	19	18	34	10	19	15	29	64	24
Did not remember	8	15	5	10	4	8	4	8	4	8	25	10
Did not respond	1	2	3	6	1	2	2	4			7	3
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

✔ **Correct answer**

Table B-112. What Should You Do? Four Units of Information on Two Frames.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	34	65	41	79	37	71	39	75	32	62	183	70
Other	8	16	5	10	11	21	7	14	13	25	44	17
Did not remember	8	15	6	11	3	6	6	11	6	11	29	11
Did not respond	2	4			1	2			1	2	4	2
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

SUBJECT DRIVERS' PREFERENCES

Table B-113. Which Message Style Do You Prefer?
Four Units of Information on One Frame Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
One frame message	26	50	22	42	29	56	26	50	31	60	134	51
Two frame message	25	48	30	58	22	42	25	48	20	38	122	47
No Preference							1	2	1	2	2	1
Did not respond	1	2			1	2					2	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Explain why

Typical comments:

Preferred One-Frame Message Style	Preferred Two-Frame Message Style
• The message is all together • Information all at one time • Easier to read • Easier to remember • Easier to understand • Can view entire message at once • It condensed the message • Stays on screen longer • Do not have to wait for the next message • Clear • Have longer time period to read • Can get all the information with one glance • Might miss the second part • Quick and to the point • Like it all at once • Do not like data being broken up • Like everything on one sign • Just one sign to look at • Stays on long enough to read while driving • Was given all at once • Less distracting • No flashing or changing • Can glance quickly and get all information • Get the whole picture at once • Easier to process information • Like message at one time due to time delay • Takes too long to read two signs	• It's split in two parts • Easier to read • Too much information for one sign • Easier for drivers to read • Information broken up and gives you time to digest it • Breaking the message up is easier to read • Easier to comprehend in parts • Less information to assimilate and process at one time • Easier to remember • More time to assess the situation • Can absorb it easily • Easier to understand • Clear • Not as much crammed on one sign • Easier to comprehend • Less to read at one time • Smaller information format • Shorter • Gives more opportunity to understand • Less confusing • Not too wordy • Flashing is an attention getter • Not as cluttered together • Not as frustrating in parts • Other sign was too clustered

Table B-114. Which Message Style Do You Prefer?
Four Units of Information on Two Frames Shown First.

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
One frame message	30	58	37	71	39	75	35	67	38	73	179	69
Two frame message	19	37	15	29	12	23	15	29	13	25	74	28
No Preference					1	2	2	4	1	2	4	2
Did not respond	3	5									3	1
TOTAL	52	100	52	100	52	100	52	100	52	100	260	100

Explain why

Typical comments:

Preferred One-Frame Message Style	Preferred Two-Frame Message Style
• **Information is all together**	• **Easier to read**
• **Easier to read**	• **Less information to read at once**
• **Easier to remember**	• **Gives you more time to read**
• **Easier to understand**	• **Was too much information on one sign**
• **Stays on the screen longer**	• **Too much to read at one time**
• **Clear**	• **Easier to remember**
• **One single message**	• **Like two lines instead of four**
• **More complete and detailed**	• **Too much to read and understand on one**
• **Information all at once**	• **Gives you more time to plan ahead**
• **Tells you everything at once, do not have to wait for the second sign**	• **More time to read the sign**
	• **If you miss the first sign, you can catch the second one**
• **Gives you more time to read**	
• **Takes less time to read**	• **Not as much to read at one time**
• **Seems like there are two problems if divided into two messages**	• **More time to absorb the message**
	• **Easier to understand and digest in two**
• **Short, blunt and to the point**	• **Less to read on each sign**
• **Get all the information up front at once**	• **Because it is broken in parts**
• **Less focus time needed**	• **Other message is too long to read quickly**
• **Flashing distracts me**	• **Doesn't cram everything onto one sign**
• **At highway speeds, easier to read**	• **Less confusing**
• **No chance to lose part of the messages**	• **More legible**
• **It did not flash**	• **Smaller parts are better to understand**

EFFECT OF REDUNDANT LANE CLOSURE INFORMATION ON DMSs WHEN LANE CONTROL SIGNALS ARE USED TO CONVEY LANE CLOSURES

First View

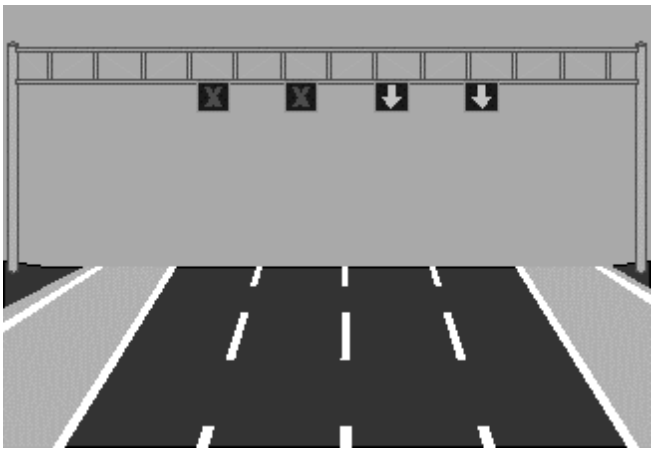


Table B-115. What Is Your Understanding of the Information the Red X's and Green Arrows Give to You?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	47	90	51	98	51	98	51	98	49	94	249	96
Other	3	6	1	2	1	2	1	2	1	2	7	3
Did not know	2	4	0	0	0	0	0	0	2	4	4	1
Did not respond	0	0	0	0	0	0	0	0	0	0	0	0
	52	100	52	100	52	100	52	100	52	100	260	100

Table B-116. What Driving Action Would You Take If You Were Driving in the Far Left Lane?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	42	81	49	94	49	94	50	96	50	96	240	92
Other	9	17	3	6	3	6	2	4	0	0	17	7
Did not know	1	2	0	0	0	0	0	0	2	4	3	1
Did not respond	0	0	0	0	0	0	0	0	0	0	0	0
	52	100	52	100	52	100	52	100	52	100	260	100

Message Displayed

ACCIDENT
AHEAD

Table B-117. What <u>New</u> Information Does the Electronic Sign on the Screen Give to You That You Did Not Get from the Information on the Sketch?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
✔Correct	46	88	47	90	42	81	46	88	46	88	227	87
Other	4	8	3	6	8	15	4	8	6	12	25	10
Did not know	1	2	2	4	1	2	2	4	0	0	6	2
Did not respond	1	2	0	0	1	2	0	0	0	0	2	1
	52	100	52	100	52	100	52	100	52	100	260	100

Table B-118. What Other Information Would You Like to See on the Sign?

Response	Dallas		El Paso		Ft Worth		Houston		San Antonio		TOTAL	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Nothing else	18	35	17	33	21	40	17	33	20	39	93	36
Distance to accident	7	13	11	21	5	10	8	15	6	11	37	14
Which lanes are closed	9	17	6	11	6	11	8	15	8	15	37	14
Slow down/caution advisory	2	4	3	6	2	4	5	10	6	11	18	7
Expected travel times, delays, or speeds	2	4	3	6	3	6	2	4	3	6	13	5
Other	14	27	12	23	15	29	12	23	9	17	62	24
	52	100	52	100	52	100	52	100	52	100	260	100

APPENDIX C: RECOMMENDED GUIDELINES

DMS OPERATING GUIDELINES

A significant amount of research and experience over the past 30 years has provided a basis of good practices that should be followed to maximize the effectiveness and credibility of DMS. The following guidelines present a summary of these good practices. These guidelines are excerpted from the following publications:

Dudek, C.L. *Guidelines on the Use and Operation of Changeable Message Signs*. Report FHWA/TX-92/1232-9. Texas Transportation Institute, College Station, Texas, November 1992**.**

Dudek, C.L. *Guidelines on the Selection and Design of Messages for Changeable Message Signs*. Report FHWA/TX-92/1232-10. Texas Transportation Institute, College Station, Texas, November 1992.

Durkop, B.R. and C.L. Dudek. *Texas Driver Understanding of Abbreviations for Dynamic Message Signs.* Report FHWA/TX-00/1882-1 (Draft). Texas Transportation Institute, College Station, Texas, February 2000.

Dudek, C.L., N.D. Trout, S. Booth, and G.L. Ullman. *Improved Dynamic Message Sign Messages and Operations.* Report No. FHWA/TX-01/1882-2 (Draft). Texas Transportation Institute, College Station, Texas, October 2000.

These references should be consulted for data supporting these guidelines and for additional information. They can be obtained by contacting the Information Technology Exchange Center at TTI (979/845-4853 or at http://tti.tamu.edu/product/catalog/).

MESSAGE DESIGN

Role of Information "Units" in Message Design

A unit of information on a DMS is a data item that a driver could recall and that could be used as a basis for making a decision. As examples:

> "ACCIDENT" is a unit of information that describes what happened
>
> "HEAVY CONGESTION" is a unit of information that describes the effect of the accident on traffic

- No more than three units of information total should be displayed to drivers ***when all three units must be recalled by drivers.***

- Four units of information may be displayed on a DMS when one of the units is minor and does not have to be remembered by drivers in order to take appropriate action to the advisory message.

- An eight-word message (about four to eight characters per word), excluding prepositions such as "TO," "FOR," "AT," etc., is about the maximum that drivers traveling at high speeds can process.

- A unit of information may be displayed on more than one line on the sign. However, a sign line should not contain more than two units of information.

- A minimum exposure time of one second per short word (four to eight characters) or two seconds per unit of information, whichever is largest, should be used for unfamiliar drivers.

Conveying Downstream Traffic Conditions to Motorists

- Use of traffic state descriptor messages "CONGESTION" and "HEAVY CONGESTION" should be reserved for when freeway congestion would not be anticipated by drivers or is more severe than expected. If used, the term "HEAVY CONGESTION" should be reserved for conditions where drivers are going to be delayed 35 minutes or more, or encounter average travel speeds downstream of 25 mph or less. For conditions less severe (but still unexpected) than these, the term "CONGESTION" should be used.

- When displaying current travel times on DMSs, the time-of-day that the travel time was measured should be included in the message (i.e., "TRAVEL TIME TO DOWNTOWN – 20 MINUTES AT 7:20 AM").

- Never display the term "FREEWAY BLOCKED" when at least one lane is open to traffic. Display it only when all lanes are blocked.

- "LANE BLOCKED" and "LANE CLOSED" are clearer than "LANE CONDITION" as a title on a DMS message.

- The word "EXIT" should be used when referring to an exit ramp on a freeway (i.e., "EXIT CLOSED"); the word "RAMP" should not be used when referring to an exit ramp from a freeway.

- It is appropriate to use the term "HIGH-PROFILE VEHICLES" when referring to vehicles that can be difficult to control by drivers in high cross winds.

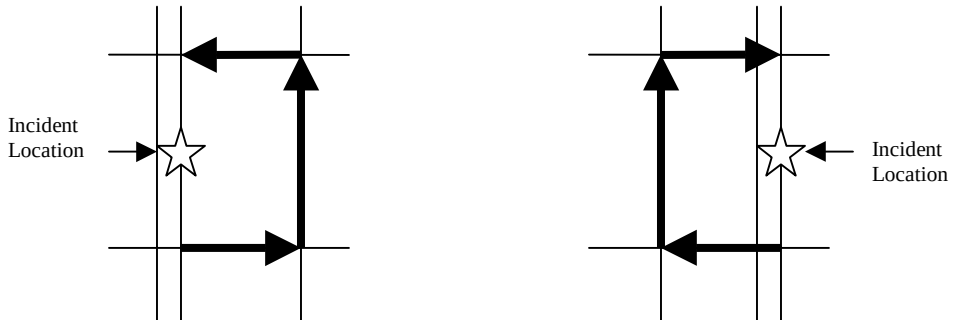
- Generally, the word "TRAFFIC" after a destination name is not necessary.

- Names used for cities on a DMS should be identical to those used on existing static signing.

Diversion Messages for Incidents

- Before diverting because of an incident, drivers desire to know the location (cross street, city) at which they will be returned to their main roadway.

- Drivers being diverted from a freeway will expect the bypass route to be a logical sequence away from the freeway, then parallel to the freeway, and then returning to the freeway. The drawing below illustrates the preferred diversion route sequence. The more common diversion route to the right away from the freeway, then parallel to the freeway, and returning to the freeway by a turning left. A diversion route that goes under the freeway (i.e., the left, parallel, and return route to the right) is also acceptable.



Diversion Route to the Right Diversion Route to the Left

- Cardinal directions (north, south, east, west) on loop freeways tend to confuse drivers.

- The route or interstate designation (I-, US, SH, FM) should always be used along with the number when referring to a roadway.

- Referring to a diversion route with a name (i.e., "BYPASS," "BUSINESS ROUTE," etc.) that implies characteristics which the facility or route does not possess weakens confidence in the signing.

Communicating Time and Day Information in DMS Messages

- Actual days of the week (e.g., TUES – FRI) should be used when the message is displayed for a work activity that will occur within the upcoming week. Calendar dates (i.e., Jan 10-Jan 12) should not be used without the names of the days shown as well.

- Actual days of the week (e.g., THURS THRU WED) should be used rather than the term "FOR 1 WEEK."

- The message term "WEEKEND" should be used only if the work is to start on Saturday morning and end by Sunday evening at midnight. Actual days and hours should be displayed on the DMS if work is to begin on Friday evening and/or continue into Monday morning.

Acceptable Abbreviations

Abbreviations well understood by drivers	Words and word combinations well understood with a prompt word (prompt word examples in parentheses)	Abbreviations with multiple interpretations (shown in parentheses) or completely misunderstood AVOID USING THESE
BLVD CNTR CONST* EMER ENT EX* EXPWY* FRWY, FWY HWY INFO LFT MAINT NORM PKING RD SERV SHLDR SLIP SPD TRAF TRVLRS WARN	(FOG, ACCIDENT) AHD* ACCDT AT* (LANE) BLKD ACCS (ROAD) ACCES RD (Bridge Name) BRDG* CHEM (SPILL) CONST (AHEAD) (TO) DWNTN (NEXT) EX, EXT EXP (LANE) FWY BLKD* HAZ (DRIVING) I (20) IH – (20) LFT LN LN CLSD MAJ (ACCIDENT, ACCDT*) MNR (ACCIDENT, ACCDT*) (20) MI (20) MIN OVSZ (LOAD) PREP (TO STOP) (WET) PVMT (AIR) QLTY RD WK* RGT LN (BEST) RT (ON) SHLDR (North Dallas) TRNPK (STALLED, EMER) VEH E, W, N, S (street name) UPR, LWR (LEVEL, LVL) WT (LIMIT)	ALT RT ACC (accident, access) DLY(delay, daily) EB, WB, NB, SB FEED RD FRNTG RD INCDT, INCID INTCH MAJ CONG LT (left, light) STAD (stadium, standard) L (left, lane) PARK (parking, park) RED (red, reduce) POLL (pollution, poll) FDR (feeder, federal) LOC (local, location) TEMP (temporary, temperature) CLRS (clears, colors) WRNG (warning, wrong) VIC

DMS OPERATING GUIDELINES

General Principles

- Don't encourage motorists to divert in order to balance demands with available capacity during recurrent congestion.

- It is better to display less information or no information at all if the sign operator is unsure of the traffic conditions.

- Make sure a recommended alternate route results in a significant improvement in travel.

- Don't tell drivers something they already know (i.e., trivial or obvious information). Telling drivers they are in congested traffic is useless information and lessens the credibility of the system.

Message Formatting Characteristics

- DMS operators should use one-frame messages whenever possible, and limit the use of two-frame messages to only those situations where the information cannot be kept to a single frame.

- When it is necessary to split a message on a portable DMS, no more than two frames should be used.

- DMS operators can choose either of two options for displaying a two-frame message on portable DMSs: either displaying each frame for four seconds each, or displaying each frame for two seconds each.

Message Display Characteristics

- Single-frame DMS messages should not be flashed in order to try and give them additional attention and target value.

- DMS operators should not flash one line of a single-frame message in order to increase its target value and attention.

- DMS operators should not present redundant information on a two-frame DMS message (i.e., keeping two lines of the message the same and changing the third line).

APPENDIX D: RECOMMENDED STANDARD MESSAGE FORMATS

INCIDENTS

DMS Located on Same Roadway Just Upstream of Incident

First Frame	**Second Frame**
ACCIDENT 1 MILE LEFT LANE BLOCKED	
ACCIDENT 1 MILE LEFT X LANES BLKD	
ACCIDENT 1 MILE RIGHT LANE BLKD	
ACCIDENT 1 MILE RIGHT X LANES BLKD	
STALLED VEHICLE ON LEFT SHOULDER 1 MILE	
STALLED VEHICLE ON RIGHT SHOULDER 1 MILE	
STALLED VEHICLE AT XXXX LEFT LANE BLOCKED	
STALLED VEHICLE AT XXXX RIGHT LANE BLOCKED	
ACCIDENT AT XXXXXX LEFT LANE BLOCKED	
ACCIDENT AT XXXX RIGHT LANE BLOCKED	
FREEWAY BLOCKED AT XXXX	AVOID DELAY USE OTHER ROUTES

Notes:

- Additional terms “MINOR,” “MAJOR,” or “TRUCK” may be added before “ACCIDENT”
- The terms “PAST” and “NEAR” can replace “AT” where appropriate
- “BLOCKED” should be replaced with “CLOSED” if response units place traffic control devices out to close the lanes.

Replace “XXXXX” with location name
Replace “X” with number of lanes blocked or closed

DMS Located on Same Roadway Far Upstream of Incident

First Frame	**Second Frame**
ACCIDENT AT XXXX 1 LANE BLOCKED	
ACCIDENT AT XXXX X LANES BLOCKED	
FREEWAY CLOSED AT XXXXX USE OTHER ROUTES	

Notes:

- Additional terms “MINOR,” “MAJOR,” or “TRUCK” may be added before “ACCIDENT”
- The terms “PAST,” “NEAR,” and “BEFORE” can replace “AT” where appropriate
- “BLOCKED” should be replaced with “CLOSED” if response units place traffic control devices out to close the lanes.

Replace “XXXXX” with location name
Replace “X” with number of lanes blocked or closed

DMS Located on Intersecting Roadway Upstream of Incident

First Frame	**Second Frame**
ACCIDENT ON XXXX REDUCE SPEED	
XXXX CLOSED AT XXXX USE OTHER ROUTES	

Replace “XXXX” with roadway names of accident location and cross-street location

ROADWORK ACTIVITIES

DMS Located on Same Roadway Just Upstream of Roadwork

First Frame	**Second Frame**
ROADWORK 1 MILE LEFT LANE CLOSED	
ROADWORK AT XXXX LEFT X LANES CLOSED	
ROADWORK 1 MILE RIGHT LANE CLOSED	
ROADWORK AT XXXX RIGHT X LANES CLOSED	
ROADWORK AT XXXX ALL LANES CLOSED	
ROADWORK ALL LANES CLOSED	EXIT AT XXXXX FOLLOW DETOUR

Notes:

- Additional terms “MINOR,” “MAJOR,” or “TRUCK” may be added before “ACCIDENT”
- The terms “PAST” and “NEAR” can replace “AT” where appropriate

Replace “XXXXX” with location name
Replace “X” with number of lanes closed

DMS Located on Same Roadway Far Upstream of Roadwork

First Frame	**Second Frame**
ROADWORK AT XXXX 1 LANE CLOSED	
ROADWORK AT XXXX X LANES CLOSED	
ROADWORK AT XXXXX ALL LANES CLOSED	

Notes:

- The terms “PAST,” “NEAR,” and “BEFORE” can replace “AT” where appropriate

Replace “XXXXX” with location name
Replace “X” with number of lanes closed

DMS Located on Intersecting Roadway Upstream of Roadwork

First Frame	**Second Frame**
ROADWORK ON XXXX REDUCE SPEED	
XXXX CLOSED AT XXXX USE OTHER ROUTES	

Replace “XXXX” with roadway names of roadwork or cross-street location