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16. Abstract This report presents recommendations to improve the design of messages for dynamic message signs (DMSs). Specifically, it presents recommendations for effective abbreviations that can be used when the required DMS message exceeds the space available on a sign. Abbreviations are especially useful in portable DMSs which have a space limitation of eight characters per line. The recommendations are made based on the results of human factors studies that were conducted in the following six TxDOT districts: Austin, Dallas, El Paso, Fort Worth, Houston and San Antonio.					
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**TEXAS DRIVER UNDERSTANDING OF ABBREVIATIONS FOR
DYNAMIC MESSAGE SIGNS**

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TABLE OF CONTENTS

LIST OF TABLES	ix
I. INTRODUCTION	1
BACKGROUND	1
PREVIOUS RESEARCH	1
RESEARCH OBJECTIVES	1
2. BACKGROUND	3
SOME DMS MESSAGE DESIGN PRINCIPLES	3
Message Components	3
Message Load	3
Message Length	4
PREVIOUS ABBREVIATION STUDIES	4
3. HUMAN FACTORS STUDY DESIGN	9
WORDS/PHRASES FOR HUMAN FACTORS STUDY	9
DESIGN OF ABBREVIATION STUDY	10
Pilot Study	10
Study Locations	10
Participants	10
Demographics	11
Placement of Words/Phrases on Study Forms	12
DATA ANALYSIS	15
Overall Analysis	15
Analysis of Words/Phrases by Location	16
4. RESULTS	17
WORD/PHRASE ABBREVIATIONS CORRECTLY INTERPRETED BY 85 PERCENT OR MORE OF ALL STUDY PARTICIPANTS	17
Overall Analysis	17
Study Location Analysis	19
WORD/PHRASE ABBREVIATIONS CORRECTLY INTERPRETED BY LESS THAN 85 PERCENT OF ALL STUDY PARTICIPANTS	19
Overall Analysis	19
Study Location Analysis	21
WORDS/PHRASES TESTED WITH ABBREVIATION ALTERNATIVES AT EACH LOCATION	22
A PORTION OF THE PHRASE ALTERED BY STUDY LOCATION	23
INTERPRETATION OF PHRASES WITH MORE THAN ONE ABBREVIATION ..	25
COMPARISON OF RESULTS TO PREVIOUS RESEARCH	28
DESCRIPTORS FOR THE ROADWAY ADJACENT TO FREEWAYS	29

5. SUMMARY OF FINDINGS AND RECOMMENDATIONS	33
RECOMMENDATIONS	33
Acceptable Abbreviations for Statewide Use in Texas	33
Acceptable Abbreviations in Specific Texas Cities Which Should Either Be Used with Caution or Should Not Be Used in Other Cities ...	33
Abbreviations That Should Not Be Used in Texas	33
6. REFERENCES	37
APPENDIX A: STUDY FORMS	39
APPENDIX B: STUDY RESULTS	47

LIST OF TABLES

Table	Page
1 Abbreviations without Prompt Words Understood by 85 Percent or More of Participants in 1983	5
2 Abbreviations with Prompt Words Understood by 85 Percent or More of Participants in 1983	6
3 Abbreviations with Prompt Words Which Were Understood by 85 Percent or More Texas Participants Tested in 1997	7
4 Comparisons of the 1983 and 1997 Abbreviation Studies	7
5 Texas Driver Age Distribution	11
6 Texas Driver Education Level Distribution	11
7 Study Participant Demographics by Location	12
8 Word/Phrase Abbreviations Interpreted by All Study Participants	13
9 Words/Phrases Tested with Abbreviation Alternatives at Each Location	14
10 Word/Phrase Abbreviation Alternatives Tested by Location	14
11 Abbreviation Words/Phrases That Were Understood by 85 Percent or More of Study Participants	18
12 Abbreviation Words/Phrases That Were Understood by Less Than 85 Percent of Study Participants	20
13 Words/Phrases Tested at Each Study Location with Multiple Abbreviation Alternatives ..	22
14 Word/Phrase Abbreviation Alternatives Tested by Study Location	24
15 Individual Abbreviations Understood by Greater Than 85 Percent of Study Participants ..	26
16 Individual Abbreviations Understood by Less Than 85 Percent of Study Participants	27
17 Comparison of Texas Abbreviation Study Results: 1983, 1997, and Current	29

Table	Page
18 Comprehension Levels for Abbreviations of Descriptors for the Roadway Adjacent to Freeways in Texas	30
19 Labels for the Roadway Adjacent to Interstates or Highways in Texas	31
20 Acceptable Abbreviations for Statewide Use in Texas	34
21 Acceptable Abbreviations for Certain Texas Cities but Should Either Be Used with Caution or Should Not Be Used in Other Cities	35
22 Abbreviations Not Recommended for Use in Texas	36

I. INTRODUCTION

BACKGROUND

The research reported herein was conducted as part of the Texas Department of Transportation (TxDOT) Research Project 0-1882 which was directed toward improving the effectiveness and utilization of dynamic message signs (DMSs). Dynamic message signs are sometimes referred to as changeable message signs or variable message signs. Often times, DMS operators must find ways to shorten messages in order to fit the relevant driver information within the limits of the DMS line space. This is even more critical on portable DMSs that are limited to eight characters per line. A useful approach to message display is to shorten selected words using abbreviations. Abbreviations must be properly designed such that drivers can interpret them. One objective of Project 0-1882 was to determine appropriate abbreviations for use on DMSs in Texas. The topic of this report addresses Texas driver comprehension of selected abbreviations for use on DMSs.

Previous studies had been conducted in Texas and elsewhere to evaluate the comprehension levels of abbreviations used in typical DMS messages, but there was still a need for further investigation due to the limited amount of current information available regarding this topic. There was a need to determine which abbreviations have comprehension levels such that they can be used in DMS messages without causing confusion to Texas drivers.

PREVIOUS RESEARCH

In 1983 and 1997, researchers conducted studies addressing the use of abbreviations in DMS messages. The data collected in 1983 by Huchingson and Dudek (1) showed that the comprehension of abbreviations for DMSs was highly dependent on the familiarity of the driver with the word. Although Texas was one of the states in which this study was conducted, the data are now dated and need to be validated for current Texas drivers. The 1997 study by Hustad and Dudek (2) was conducted for the New Jersey Department of Transportation. Only a small sample of the Texas drivers was included in the New Jersey DOT study to analyze the perceptions of out-of-state drivers.

RESEARCH OBJECTIVES

The specific objectives of the research were to:

- identify words/phrases that are currently abbreviated on DMSs by TxDOT;
- identify words/phrases that may be abbreviated by TxDOT on DMSs in the future;
- select words/phrases for further study;
- conduct a human factors study to test Texas driver comprehension of the selected words/phrases;
- determine which abbreviations have acceptable Texas driver comprehension levels; and
- make recommendations for abbreviations to be used on DMSs by TxDOT.



2. BACKGROUND

SOME DMS MESSAGE DESIGN PRINCIPLES

Message Components

A basic DMS message is the totality of information that the motorists will need on the DMS in order to make a rational driving decision (e.g., whether to take an alternative route). The following message elements are necessary for the basic DMS message when an accident occurs on the primary roadway (3):

- an incident descriptor;
- location of incident;
- lanes affected;
- effect on travel (major delay, etc.);
- audience for the action statement (addresses a certain group, not always necessary);
- action (what the driver should do); and
- one good reason for following the action statement.

In most cases, the basic DMS message will exceed the minimum amount of informational units that can be displayed on a DMS which will allow the drivers to read, understand, and react to the message. Therefore, the basic DMS message must be reduced in length.

Message Load

Message load can be interpreted as the number of information units that are contained in a DMS message. A unit of information can contain from one to four words. The following example illustrates the concept of units of information as would be contained in a DMS message (4):

<u>Question</u>	<u>Information Unit Required</u>
1. What happened?	Accident
2. Where?	At Milford Street
3. What effect on traffic?	Heavy Congestion
4. Who is the advisory intended for?	Utopia Traffic
5. What is advised?	Use Williams Street

This example contains five units of information. Studies have indicated that at speeds greater than 35 mph, drivers can read and process only four units of information (5). Therefore, it is necessary

to determine the elements of the message which are crucial for the given situation and to develop a message providing this information in the appropriate number of units of information.

Message Length

One factor that must be considered in message design is the limited space available for displaying the message and the use of abbreviations. Often, the DMS with the least available space is the portable message sign which has three lines of eight characters each for displaying a message. Therefore, the message line length of eight characters is frequently used as a gauge for how short abbreviated words/phrases should be.

Although studies of reading behavior showed that abbreviations take a greater amount of time to read than the full word, there are circumstances that dictate their use in DMS messages. These include (2):

- the word/phrase length exceeds the physical capacity of the DMS; and
- the number of message frames must be reduced.

When abbreviations are used in DMS messages, consideration must be given to the increase in driver information load as associated with the abbreviations. If an abbreviation is not well understood by drivers, the intended message will not be clear. Also, it has been shown that abbreviations take between 800 and 1000 milliseconds to read. This is longer than the average reading rate, which is 450-500 milliseconds per word (6).

PREVIOUS ABBREVIATION STUDIES

There have been two previous studies conducted on the topic of DMS abbreviations in the state of Texas. One was conducted in 1983 by Huchingson and Dudek with the objective of developing a dictionary of abbreviations that could be used on DMSs nationwide. This study indicated that the success of an abbreviation dictionary would be highly dependent on the familiarity of the user with the words in the vocabulary (1).

The study by Huchingson and Dudek was conducted in two parts. In the first part of the study, subjects were provided with the list of selected words and asked to create abbreviations that would be easily understood by drivers. In the second part, the most commonly developed abbreviations from part one of the study were given to a second group of subjects who were then asked to provide the researchers with the full word. This was done initially by giving the abbreviation alone and then by giving the word along with a prompt word. The prompt word was an unabbreviated word that commonly appears either before or after the abbreviated word on highway signs. The intention of the prompt word was to help clarify the context of the abbreviation and thereby to increase understanding (1).

The results of the study showed that when the words were commonly abbreviated by the participants in the same manner, they were well understood when additional participants were asked to provide the full word from these abbreviations. Also, it was found that longer words had low agreement when the participants were asked to create abbreviations. The abbreviations of longer words tended to be less efficient due to their length, and researchers found that abbreviations that exceed two-thirds of the word's length should be avoided. Researchers recommended that if the abbreviation is longer than two-thirds of the word length, a synonym for the word should be considered (1).

When this study was administered to 25 subject drivers in Texas in 1983, 21 abbreviations were identified that were understood by 85 percent of participants or better. An additional 47 words were added to this list when a prompt word was given along with the abbreviation. A caution was given that if the word was found to have adequate comprehension only with a prompt word, it should be used only with the exact prompt word that was tested to ensure the same level of understanding among participants (1).

Table 1 contains the list of abbreviations that were identified appropriately by 85 percent or more of participants without the use of prompt words. Table 2 contains the 47 additional words that were understood with the use of a prompt word, as well as the prompt word that was used.

Table 1. Abbreviations without Prompt Words Understood by 85 Percent or More of Participants in 1983 (1).

Word	Abbreviation	Word	Abbreviation
Boulevard	BLVD	Normal	NORM
Center	CNTR	Parking	PKING
Emergency	EMER	Road	RD
Entrance	ENT	Service	SERV
Expressway	EXPWY	Shoulder	SHLDR
Freeway	FWY	Slippery	SLIP
Freeway	FRWY	Speed	SPD
Highway	HWY	Traffic	TRAF
Information	INFO	Travelers	TRVLRS
Left	LFT	Warning	WARN
Maintenance	MAINT		

Table 2. Abbreviations with Prompt Words Understood by 85 Percent or More of Participants in 1983 (1).

Original Phrase	Prompt Word and Abbreviation	Original Phrase	Prompt Word and Abbreviation
Access Road	ACCS ROAD	15 Minutes	15 MIN
Fog Ahead	FOG AHD	Minor Accident	MNR ACCIDENT
Lane Blocked	LANE BLKD	Normal Traffic	NORM TRAFFIC
Buckner Boulevard	BUCKNER BLVD	Oversized Load	OVRSZ LOAD
Washington Bridge	WASHINGTON BRDG	Coliseum Parking	COLISEUM PKING
Chemical Spill	CHEM SPILL	Prepare to Stop	PREP TO STOP
Center Lane	CNTR LANE	Wet Pavement	WET PVMT
Construction Ahead	CONST AHEAD	Air Quality	AIR QLTY
Emergency Vehicle	EMER VEHICLE	Krenek Road	KRENEK RD
Freeway Entrance	FREEWAY ENT	Best Route	BEST RT
Next Exit	NEXT EX	Keep Right	KEEP RT
Express Lane	EXP LANE	Service Road	SERV ROAD
Next Exit	NEXT EXT	Soft Shoulder	SOFT SHLDR
North Expressway	NORTH EXPWY	Slippery Pavement	SLIP PAVEMENT
Harbor Freeway	HARBOR FRWY	Speed Limit	SPD LIMIT
Harbor Freeway	HARBOR FWY	Traffic Advisory	TRAF ADVISORY
Hazardous Driving	HAZ DRIVING	Turner Turnpike	TURNER TRNPK
Highway 6	HWY 6	Travelers Warning	TRVLRS WARNING
Interstate 25	I 25	Township Limits	TWNSHIP LIMITS
Traffic Information	TRAFFIC INFO	Upper Level	UPR LEVEL
Merge Left	MERGE LFT	Stalled Vehicle	STALLED VEH
Maintenance Work	MAINT WORK	29 th West	29 TH W
Major Accident	MAJ ACCIDENT	Blizzard Warning	BLIZZARD WARN
3 Miles	3 MI		

In 1997, research was conducted by Hustad and Dudek (2) using subject motorists in New Jersey and Texas. The abbreviations contained in Table 3 were understood by 85 percent of the participants in the Texas portion of the study.

Table 3. Abbreviations with Prompt Words Which Were Understood by 85 Percent or More Texas Participants Tested in 1997 (2).

Message Phrase	Abbreviation	Message Phrase	Abbreviation
No Access	NO ACCS (or NO ACC)	Left Lane	LFT LN
Alternate Routes	ALT RTS (or ALT RTES)	Right Lane	RGT LN (or RT LN)
Arts Center	ARTS CTR	Road Work	RD WK
[name] Aquarium	[name] AQRM	To Route [number]	TO RT [number]
Center Lane	CTR LN	On Shoulder	ON SHLDR
Construction	CONST	Parking Lot	PK LOT (or PARK LOT)
Emergency Vehicle	EMER VEH	Truck Stop	TRK STOP
Garden State Parkway	GRDN ST PKWY	To Turnpike	TO TRPK
Interstate [number]	I-[number] (or I [number])	Weight Limit	WT LIMIT
Lane Closed	LANE CLSD		

Several of the terms which were found to be well understood in the 1997 study had been previously tested in the 1983 study. In many of the cases, the prompt word for the phrase had been changed between the two studies. The comparisons contained in Table 4 can be made between the results of the 1997 study and the 1983 study.

Table 4. Comparisons of the 1983 and 1997 Abbreviation Studies (1, 2).

Original Word/Phrase	1983 Study		1997 Study	
	Abbreviation and Prompt Word From Texas	Percent Understanding Abbreviation	Abbreviation and Prompt Word From Texas	Percent Understanding Abbreviation
Access	ACCS ROAD	88	NO ACCS	95
Construction	CONST CONST AHEAD	76 92	CONST	95
Emergency Vehicle	EMER VEHICLE	100	EMER VEH	93
Route	RT BEST RT	38 86	TO RT [number]	93

Access was abbreviated *ACCS* for each study. In the 1983 study, the prompt word was *road*, while in the 1997 study the prompt word was *no*. Even with the change of prompt word, *ACCS* was found to be understood for “access” in both studies by 88 and 95 percent, respectively, of the participants.

Construction was also tested in both of the studies, although in the earlier study it was found to be understood by only 76 percent of the participants when it was presented alone as compared to 95 percent in 1997. In 1983, it was also tested with *ahead* as a prompt word and was found to be understood by 92 percent of the study participants.

Emergency vehicle was tested in 1983 where emergency was abbreviated as *EMER* and vehicle was spelled out as the prompt word. In this case, the phrase was found to be understood by 100 percent of the participants in the study. In 1997, both terms were abbreviated as *EMER VEH*, which was found to be understood by 93 percent of the participants. It should be noted that when *VEH* was tested individually in 1983, it was understood by only 80 percent of the participants.

When *route* was abbreviated as *RT* in the 1983 study and tested without a prompt word, it was found to be understood by only 38 percent of the participants, with 62 percent believing that it stood for *right*. When used with the prompt word *best*, it was found to be understood by 86 percent of the participants. Again, when *RT* was tested in 1997 in the form *TO RT [number]*, it was found to be understood by 93 percent of the participants. In this case, the prompt word had a significant impact on the understanding of the abbreviation and should be observed carefully when abbreviating *route* as *RT*.

3. HUMAN FACTORS STUDY DESIGN

WORDS/PHRASES FOR HUMAN FACTORS STUDY

The abbreviations currently being used on DMSs in Texas were identified by examining DMS message logs and/or libraries provided by the following seven TxDOT offices located in metropolitan areas of Texas: Austin, El Paso, Fort Worth, Houston, Laredo, Pharr, and San Antonio. Unfortunately, message logs or libraries were not available for portable DMSs. A list of critical abbreviated words/phrases for this study was developed by TTI researchers with concurrence of the TxDOT Project Director and Advisory Committee.

Shown below is the list of phrases that were selected for the human factors abbreviations studies. The words shown in capital letters were abbreviated in the studies; those shown in italics were not abbreviated.

ACCIDENT <i>at</i>	INTERCHANGE 14A
ACCESS <i>road</i>	INTERSTATE 35
<i>fog</i> AHEAD	LANE CLOSED
ALTERNATE ROUTES	LOWER <i>level</i>
BELTWAY 8	MAJOR ACCIDENT
_____ BRIDGE	MINOR ACCIDENT
_____ BOULEVARD	NORTHBOUND (SOUTHBOUND, etc.) <i>traffic</i>
<i>major</i> CONGESTION	OVERSIZED <i>load</i>
CONSTRUCTION	2 MILES
CENTER (RIGHT, LEFT) LANE	15 MINUTE <i>delay</i>
DETOUR ROUTE	PARKING <i>lot</i>
<i>to</i> DOWNTOWN	<i>wet</i> PAVEMENT
EMERGENCY VEHICLE	PREPARE <i>to stop</i>
EXIT 30	ROAD WORK
EXPRESSWAY CLOSED	SERVICE <i>road</i>
FEEDER ROAD	<i>on</i> SHOULDER
FREEWAY BLOCKED	TRAFFIC CLEARS
FRONTAGE <i>road</i>	TRUCK STOP
<i>hempstead</i> HIGHWAY	UPPER <i>level</i>
HIGH OCCUPANCY VEHICLE <i>lane</i>	VICINITY <i>of</i>
INCIDENT <i>at</i>	WEIGHT <i>limit</i>

The words/phrases were categorized in the following three forms: 1) a single abbreviated word, 2) more than one abbreviated word together to form a phrase, or 3) inclusion of a prompt word, which is an unabbreviated word used to aid in the comprehension of the abbreviations. Examples are:

1. CONST (construction),
2. MAJ CONG (major congestion), and
3. EXPWY CLOSED (expressway closed).

DESIGN OF ABBREVIATION STUDY

Following the selection of the words/phrases, a study was developed for the purpose of testing Texas driver comprehension of the selected abbreviations. The study was designed such that each driver subject was provided with the selected abbreviations and asked to determine the abbreviated word/phrase. Four separate study forms were developed. These are shown in Appendix A. The words/phrases were listed randomly using a random number generator for each of the forms to minimize the bias that might occur due to the placement of a word/phrase on the study form.

Pilot Study

Initially, a pilot study was conducted to ensure that the instructions and the format of the study instrument were clear to the participants and to ensure that the desired information was obtained. The pilot study was conducted at the Department of Public Safety Office in Bryan, Texas, and was administered to 45 participants. The results of the pilot study indicated that there were no problems with the basic concept of the study instrument. However, there were some minor misinterpretations by the study participants concerning the type of information that was being requested by the researchers. Instead of simply providing a full word for the given abbreviation, the participants sometimes attempted to define the meaning of the word/phrase that was abbreviated, which created confusion for the interpretation of the results. To eliminate this problem, an example was added prior to the questions in order to clarify the type of answer that was desired. Also, based on the responses given for some of the abbreviations, alternatives were added for selected words/phrases in order to determine if the comprehension levels could be improved.

Study Locations

Following the completion of the pilot study, the study was conducted in the following six Texas cities: Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio. These locations were selected on the basis that they were major metropolitan regions of Texas that were currently using DMSs to provide real-time information to drivers.

Participants

At each study location, 50 participants were recruited from the local Texas Department of Public Safety Office through direct one-on-one contact. Texas drivers were asked to participate in the study while waiting to process paperwork at the drivers' licensing office or while waiting for a companion to complete a driving examination. All participants were asked their preference as to completing the form themselves or having a researcher record their responses. The qualifications required for

participants were that they had a current Texas driver's license, drove more than 8,000 miles per year, and traveled on interstate highways at least 12 times a year.

Demographics

The study participants were selected according to a demographic sample of the driving population in Texas with regard to gender, age, and education level. Tables 5 and 6 contain statistics obtained from the Texas Department of Public Safety regarding driver age and from the 1990 United States census regarding education level, respectively. Gender statistics showed that there was an even split of male versus female drivers. This was reflected in the demographic sample by obtaining 25 participants of each gender for each study location.

Table 5. Texas Driver Age Distribution (7).

Age Group	Percentage of Drivers
< 25	15
25-39	35
40-54	28
55-64	10
65+	12

Table 6. Texas Driver Education Level Distribution (8).

Education Level	Percentage of Drivers
No High School Diploma	28
High School Diploma	26
Some College	23
College Degree	23

The data shown in Tables 5 and 6 are representative of the overall age and education statistics for the Texas driving population. Since these data were not available in a format that cross-referenced the statistics for age, education, and gender, a cross-referenced data sample was created by the researchers. Table 7 contains the cross-referenced demographic sample that was used at each study location.

Table 7. Study Participant Demographics by Location.

Age Category	Education Level								Total
	No High School		High School		Some College		College Degree		
	M	F	M	F	M	F	M	F	
<25	1	2	1	1	1	0	1	0	7
25-39	2	2	2	2	3	2	2	3	18
40-54	2	2	2	2	1	2	1	2	14
55-64	1	0	1	1	0	1	1	0	5
65+	1	1	1	0	1	1	0	1	6
Total	7	7	7	6	6	6	5	6	50

Placement of Words/Phrases on Study Forms

There were 42 words/phrases analyzed in this study. Not all of the word/phrase abbreviations were seen by each participant during the study. Participants selected to interpret a given word/phrase abbreviation were determined in one of three ways:

- one word/phrase abbreviation was interpreted by all participants at all six study locations;
- two alternative word/phrase abbreviations were studied. In this case, half of the subjects at each study location interpreted the first alternative and the other half interpreted the second alternative; or
- a portion of the phrase abbreviation was changed to create abbreviation alternatives that were tested by location. In this case, all of the participants at a single location interpreted the same abbreviation, but the abbreviation was changed according to study location.

An abbreviation was interpreted by all of the participants when no alternatives were being studied for that word/phrase. The words/phrases tested with this method are provided in Table 8. The words given in capital letters in the first column of this table were abbreviated in the study, while those shown in italics were not abbreviated. The italicized words are prompt words that would appear on the DMSs along with the abbreviation to aid in comprehension.

For the word/phrase abbreviations that were being tested as two abbreviation alternatives at each study location, each of the alternatives was provided on two of the four study forms. Table 9 contains the word/phrases that were tested using this method. Again, the words given in capital letters in the first column of this table were abbreviated in the study, while those shown in italics were not abbreviated. It should be noted that the alternatives for “upper level” and “lower level” were changed for the second half of the study in order to test a third option for the abbreviations. This was

done in order to have an abbreviation alternative that was eight characters long that would, therefore, fit on a portable DMS.

Table 8. Word/Phrase Abbreviations Interpreted by All Study Participants.

Word/Phrase	Abbreviation(s) Studied
ACCIDENT <i>at</i>	ACCDT <i>AT</i>
ACCESS ROAD	ACCES RD
<i>fog</i> AHEAD	<i>FOG</i> AHD
ALTERNATE ROUTES	ALT RTS
BELTWAY 2	BLTWY 2
<i>mason</i> BRIDGE	<i>MASON</i> BRDG
MAJOR CONGESTION	MAJ CONG
CONSTRUCTION	CONST
<i>to</i> DOWNTOWN	<i>TO</i> DWNTN
EMERGENCY VEHICLE	EMER VEH
EXIT <i>30</i>	EX <i>30</i>
EXPRESSWAY <i>closed</i>	EXPWY <i>CLOSED</i>
FEEDER ROAD	FEED RD
FREEWAY BLOCKED	FWY BLKD
FRONTAGE ROAD	FRNTG RD
<i>hempstead</i> HIGHWAY	<i>HEMPSTEAD</i> HWY
HIGH OCCUPANCY VEHICLE <i>lane</i>	HOV <i>LANE</i>
INTERCHANGE <i>14</i>	INTCH <i>14</i>
INTERSTATE 35	I-35
LANE CLOSED	LN CLSD
MAJOR ACCIDENT	MAJ ACCDT
MINOR ACCIDENT	MNR ACCDT
OVERSIZED <i>load</i>	OVSZ <i>LOAD</i>
2 MILES	2 MI
<i>15</i> MINUTE <i>delay</i>	<i>15</i> MIN <i>DELAY</i>
PARKING <i>lot</i>	PRK <i>LOT</i>
<i>wet</i> PAVEMENT	<i>WET</i> PVMT
PREPARE <i>to stop</i>	PREP <i>TO STOP</i>
ROAD WORK	RD WK
SERVICE <i>road</i>	SERV RD
<i>on</i> SHOULDER	<i>ON</i> SHLDR
TRAFFIC CLEARS	TRAF CLR
TRUCK <i>stop</i>	TRK <i>STOP</i>
VICINITY <i>of</i>	VIC <i>OF</i>
WEIGHT <i>limit</i>	WT <i>LIMIT</i>

Table 9. Words/Phrases Tested with Abbreviation Alternatives at Each Location.

Word/Phrase	Abbreviation #1	Abbreviation #2
<i>detour</i> ROUTE	DETOUR RT	DETOUR RTE
INCIDENT <i>at</i>	INCID AT	INCDT AT
LOWER LEVEL	LOWER LVL (or LOWR LVL)*	LWR LEVEL
UPPER LEVEL	UPPER LVL (or UPPR LVL)*	UPR LEVEL

* In these cases, the first abbreviation alternative was changed for the second half of the study.

The third interpretation option occurred when a portion of the abbreviation phrase was changed by location. For example, *LFT LN* was changed to *RGT LN* in order to test *left lane* and *right lane*, respectively. Each of the abbreviation alternatives tested was provided at either one, two, or three of the study locations depending on the number of alternatives that were being examined for a selected phrase. Under these circumstances, all of the participants at a given study location interpreted the same abbreviation, but between study locations, a portion of the phrase was changed in order to test further options. Table 10 contains the word/phrases that were tested by this method as well as the locations where each was tested. Note that IH-20 was added for the second half of the study as an option for the abbreviation of *interstate* and was therefore tested at only three of the study locations.

Table 10. Word/Phrase Abbreviation Alternatives Tested by Location.

Word/Phrase	Abbrev.	Location(s) Tested
<i>king</i> BOULEVARD	KING BLVD	Austin, Houston, San Antonio
<i>penn</i> BOULEVARD	PENN BLVD	El Paso, Dallas, Ft. Worth
CENTER LANE	CTR LN	El Paso, Houston
LEFT LANE	LFT LN	Austin, Dallas
RIGHT LANE	RGT LN	Ft. Worth, San Antonio
INTERSTATE 20	IH-20	El Paso, Dallas, Ft. Worth
EASTBOUND <i>traffic</i>	EB TRAFFIC	Austin
NORTHBOUND <i>traffic</i>	NB TRAFFIC	Houston
SOUTHBOUND <i>traffic</i>	SB TRAFFIC	San Antonio
US 180 EASTBOUND	US 180 EB	Ft. Worth
US 75 NORTHBOUND	US 75 NB	Dallas
US 75 SOUTHBOUND	US 75 SB	El Paso

DATA ANALYSIS

Overall Analysis

The participants' responses were combined from all six of the study locations for each of the abbreviated words/phrases and were examined to find the percentage of correct responses for each of the abbreviations. In cases where a given phrase contained more than one abbreviated word, both the phrase and each individual word were analyzed for correct responses. Abbreviations were considered acceptable for use on DMSs in Texas when 85 percent of the total study participants correctly interpreted the word/phrase abbreviation. The 85 percent criterion was based on the threshold used by Dudek, Huchingson, et al. (4) and is often used for traffic engineering design purposes.

When an abbreviation was determined to have a comprehension level that was less than 85 percent, a confidence interval test was used to determine if the comprehension percentage was statistically different from the 85 percent criterion. The following confidence interval formula was used in establishing the boundaries for this statistical test (9):

$$p - 1.96 * \sqrt{\frac{p*(1-p)}{n}} < p_0 < p + 1.96 * \sqrt{\frac{p*(1-p)}{n}}$$

where: p_0 = true percent correct response considering error,
 p = sample percent correct response, and
 n = total number of respondents.

If 0.85 fell within the boundaries of the confidence interval, then the level of comprehension for the tested abbreviation was not statistically different from 85 percent using a level of significance of α equals 0.05. The term level of significance, α , indicates the probability of the test giving an incorrect response. When using an α equal to 0.05, the researcher is asserting that the result of the test will be correct 95 percent of the time.

When more than one abbreviation alternative was tested for a given word/phrase, a statistical test was performed to determine if there was a statistical difference between the alternatives. This was especially important when one of the possible abbreviations was found to be greater than 85 percent, while the other was not. The statistical test that was applied was the Bernoulli model. The test is designed to compare two Bernoulli proportions (p_1, p_2), of independent random samples using the following test statistic (9):

$$Z = \frac{f_1/n_1 - f_2/n_2}{\sqrt{\frac{f_1 + f_2}{n_1 + n_2} \left(1 - \frac{f_1 + f_2}{n_1 + n_2}\right) \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where: f_1 = number of correct responses from alternative 1,
 f_2 = number of correct responses from alternative 2,
 n_1 = total number of respondents in alternative 1, and
 n_2 = total number of respondents in alternative 2.

The null hypothesis tested was that the Bernoulli proportion for alternative 1 was equal to the Bernoulli proportion for alternative 2. The alternate hypothesis for this test was that the Bernoulli proportion for alternative 1 was not equal to the Bernoulli proportion for alternative 2. The null hypothesis was rejected if the test statistic, Z , was greater than 1.96. This value was selected as the critical value for the test statistic using a level of significance of α equal to 0.05. Rejection of the null hypothesis indicated that there was a statistically significant difference in comprehension levels between the two study locations.

Analysis of Words/Phrases by Location

When the abbreviation word/phrase was determined to have an overall comprehension level for Texas that was 85 percent or greater, an analysis was performed to examine the comprehension level at each individual study location to determine if the individual comprehension level was less than 85 percent. When an individual study location was determined to have a comprehension level that was less than 85 percent for a given abbreviation, the confidence interval test, explained previously, was again applied to determine if the comprehension level at the individual study location was statistically different from 85 percent.

A second statistical test was performed using pairwise comparisons to relate the comprehension levels from each of the study locations to all of the other study locations as proportions of independent samples. By comparing the comprehension levels from those at the individual study locations in this manner, it could then be determined if the comprehension level at one location was statistically different from the other locations. The test used for this analysis was the Bernoulli model, which was explained previously. For this test, the alternatives, mentioned in the previous explanation, would be the study locations.

Further examination was also made regarding the demographics of participants when the comprehension levels for any of the studied abbreviations were noted to have significant differences between individual study locations, for example when some of the study locations were greater than 85 percent while others were less than 85 percent. The demographics for these word/phrase abbreviations were examined to determine the age and education level characteristics for those responding correctly and incorrectly at each of the locations. This was done in order to identify trends in education level or age for the respondents at the study location with the differing comprehension level.

4. RESULTS

The primary discussion in this section concerns the overall percentage of participants who correctly identified the abbreviated words/phrases. Overall percentage implies that all of the study locations have been combined in order to determine one statewide comprehension level. This section is divided based on the three testing methods described in the Human Factors Study Design chapter: 1) word/phrase was interpreted by all study participants, 2) multiple abbreviation alternatives were tested at each location, and 3) a portion of the abbreviation phrase was altered by study location. Complete tables containing all participant responses are contained in Appendix B. The tables in Appendix B include the frequency of different responses for each of the abbreviated words/phrases and are separated by study location.

WORD/PHRASE ABBREVIATIONS CORRECTLY INTERPRETED BY 85 PERCENT OR MORE OF ALL STUDY PARTICIPANTS

Overall Analysis

The abbreviation was interpreted by all 300 study participants when only one alternative was studied for a given word/phrase. Table 11 contains the abbreviated words/phrases that were tested in this manner and that were understood by 85 percent or more of the Texas drivers who were tested. The shaded areas of the table contain individual study location comprehension percentages that were less than 85 percent.

The abbreviation *TRAF CLR* for *traffic clear* was also included in Table 11. Although it had a comprehension level of only 82 percent overall, this was not statistically different from 85 percent. It should be noted that the confidence interval test using the 85 percent criterion creates an interval of ± 4 percent when $n = 300$, and of ± 10 percent for the individual study locations when $n = 50$.

In the case of *ACCDT AT*, the abbreviation was interpreted correctly as *accident at* by only 76 percent of the participants in this study. However, an additional 12 percent of the participants had correctly interpreted *ACCDT* as *accident* but also attempted to interpret *AT* as if it were an abbreviation. The authors believe that had *ACCDT AT* been followed by additional information (e.g., location of the accident), this misinterpretation would not have occurred. Therefore, these latter responses were considered correct for the *ACCDT* abbreviation and resulted in an 88 percent correct response in this analysis.

Table 11. Abbreviation Words/Phrases That Were Understood by 85 Percent or More of Study Participants.

Original Word/Phrase	Abbreviation	Comprehension Percentages						
		Dallas n=50	Fort Worth n=50	Houston n=50	El Paso n=50	Austin n=50	San Antonio n=50	Total n = 300
2 miles	2 MI	94	96	94	96	90	96	94
15 minute delay	15 MIN DELAY	98	94	96	92	90	98	95
access road	ACCES RD	96	94	96	90	96	96	95
accident at	ACCDT AT	96	96	86	90	84*	78*	88
construction	CONST	92	90	76*	86	86	80*	85
emergency vehicle	EMER VEH	96	96	86	92	96	88	92
expressway closed	EXPWY CLOSED	92	94	88	64	82*	90	85
freeway blocked	FWY BLKD	88	92	92	88	74	84*	86
fog ahead	FOG AHD	90	94	84*	84*	94	92	90
Hempstead Highway	HEMPSTEAD HWY	100	96	100	90	86	94	94
Interstate 35	I-35	92	100	90	86	88	88	91
lane closed	LN CLSD	98	98	94	86	92	88	93
Mason Bridge	MASON BRDG	88	82*	90	84*	88	90	87
major accident	MAJ ACCDT	98	98	96	86	94	94	94
minor accident	MNR ACCDT	92	90	86	92	82*	90	89
on shoulder	ON SHLDR	96	94	100	88	86	96	93
oversize load	OVSZ LOAD	92	88	88	94	92	88	90
parking lot	PRK LOT	100	100	98	98	98	98	99
prepare to stop	PREP TO STOP	100	98	94	100	94	98	97
service road	SERV RD	98	96	96	90	90	88	93
to downtown	TO DWNTN	98	92	94	90	90	86	92
traffic clear	TRAF CLR	88	78*	82*	76*	80*	90	82*
truck stop	TRK STOP	82*	86	76*	92	90	92	86
weight limit	WT LIMIT	88	94	88	86	88	92	89
wet pavement	WET PVMT	100	85	96	92	98	98	95

* Based on a confidence interval test, these were not statistically different than 85 percent at α equal 0.05.
 Note: Shading indicates comprehension percentages that were less than 85 percent.

Study Location Analysis

Individual study locations were examined for the abbreviations contained in Table 11 in order to determine if each study location had comprehension levels equal to or greater than 85 percent. Although the abbreviations had overall comprehension levels greater than or equal to 85 percent, individual study locations were not always found to meet this criterion. The shaded areas of Table 11 contain the comprehension percentages that were less than 85 percent at a given study location.

Statistical tests were conducted on these data to determine if the observed study location differences had statistical significance. Using the confidence interval test explained in the Human Factors Study Design, it was found that the comprehension levels in El Paso for *EXPWY CLOSED* (64 percent) and in Austin for *FWY BLKD* (74 percent) were statistically below the 85 percent comprehension level. All of the other study location percentages that were below 85 percent were not found to be statistically different from 85 percent.

When a pairwise comparison was done on the data from each study location using the Bernoulli statistical test, the only clear difference detected was that El Paso was significantly different from all of the other study locations for *EXPWY CLOSED*.

In the cases of *EXPWY CLOSED* and *FWY BLOCKED*, it was found that the participants who misinterpreted the abbreviation were in the lower education demographics 71 and 79 percent of the time, respectively. The lower education demographics include drivers who have no high school diploma or who have a high school diploma but have not attended college.

A trend related to age was also identified for the participants who misinterpreted *EXPWY CLOSED* in El Paso. It was determined that 82 percent of the El Paso participants who misinterpreted this abbreviation were less than 40 years of age. No explanation can be determined for this trend. No other distinct demographic age trends were observed for the study location misinterpretations.

WORD/PHRASE ABBREVIATIONS CORRECTLY INTERPRETED BY LESS THAN 85 PERCENT OF ALL STUDY PARTICIPANTS

Overall Analysis

Table 12 contains abbreviations that were understood by less than 85 percent of the 300 study participants. When an abbreviation was frequently misinterpreted by participants in the same manner, the most common misinterpretation is shown in the table. Any interpretation that is not mentioned was given by participants less than 5 percent of the time. The shaded areas of the table again contain comprehension levels that were inconsistent at individual study locations. In this case, the shaded areas are comprehension levels that are greater than 85 percent.

Table 12. Abbreviation Words/Phrases That Were Understood by Less Than 85 Percent of Study Participants.

Word/Phrase	Abbreviation	Comprehension Percentages							Other Common Interpretations (%)
		Dallas n=50	Fort Worth n=50	Houston n=50	El Paso n=50	Austin n=50	San Antonio n=50	Total n=300	
Alternate Routes	ALT RTS	82*	84*	66	60	64	76*	72	did not know (12)
Beltway 2	BLTWY 2	74	58	98	22	58	48	60	did not know (31)
Exit 30	EX 30	78*	72	84*	82*	74	88	80	did not know (5)
Feeder Road	FEED RD	38	40	72	8	46	40	41	feed road (52)
Frontage Road	FRNTG RD	80*	76*	74	48	78*	62	70	front road (6) ? road (11) did not know (9)
High Occupancy Vehicle Lane	HOV LANE	34	48	40	0	16	12	25	hover lane (5) did not know (39)
	understood lane use concept ^a	70	68	64	0	28	16	41	
Interchange 14	INTCH 14	34	52	26	22	30	28	32	inch 14 (9) intersection 14 (8) did not know (43)
Major Congestion	MAJ CONG	54	60	38	60	48	60	53	major construction (9) major ? (9) did not know (15)
Road Work	RD WK	76*	88	80*	74	86	80*	81	road walk (9)
Vicinity of	VIC OF	18	18	12	6	26	18	16	did not know (69)

* Based on a confidence interval test, these were not statistically different than 85 percent at α equal 0.05.

^a Includes participants who were able to correctly interpret the abbreviation and participants who were able to describe how the lane was regulated for use.

Note: Shading indicates comprehension percentages that were greater than 85 percent.

A confidence interval test was conducted for the abbreviations that were understood by less than 85 percent of the participants. This testing was done to ensure that, statistically, the comprehension levels were below the 85 percent criterion. It was found that all of the abbreviations contained in Table 12 were statistically lower than the 85 percent level.

A few of the abbreviations shown in Table 12 require discussion in order to explain trends detected during the overall analysis of the responses.

FEED RD - The term *feeder road* was correctly interpreted for this abbreviation by only 41 percent of the participants. As was noted in the table, instead of *feeder road*, *feed road* was given as a response 52 percent of the time. The authors decided that this could not be considered a correct response since it could not be determined if the abbreviation was simply copied over and considered to be a full proper name for a roadway or if participants were referring to a roadway that feeds into a highway.

HOV LANE - This abbreviation for *High Occupancy Vehicle Lane* was understood by only 25 percent of the overall participants in this study. It should be noted that when the study participants were asked if they could describe the use for the HOV lane that the comprehension level increased to 41 percent of the participants understanding the abbreviation. Also, in cities with HOV lane facilities, which include Houston, Dallas, and Fort Worth, this comprehension level increased to 68 percent when an average was determined for these three locations.

Study Location Analysis

Study location analysis was also done when the abbreviations had overall comprehension levels less than 85 percent. When these abbreviations were analyzed by study location, individual study locations were found to be greater than or equal to 85 percent. The shaded areas of Table 12 contain the individual study locations where the comprehension percentages were greater than 85 percent. Specific results are discussed in the following sections.

ALT RTS - This abbreviation for *alternate routes* did not have individual study locations with comprehension levels greater than 85 percent, but Dallas, Fort Worth, and San Antonio were not statistically different from the 85 percent criterion. No explanation for this difference can be determined.

BLTWY 2 - This abbreviation for *Beltway 2* was influenced by the study location geography of the study participants. Overall, the abbreviation was understood by only 60 percent of the participants. However, Houston and El Paso were both statistically different from the other study locations. For Houston this phenomenon occurred because of the large percentage of participants who understood this abbreviation at 98 percent, while in El Paso, the difference was that there was a very low comprehension level at only 22 percent. The difference noticed in the Houston area can be attributed to the fact that this term is in common use in Houston.

FRNTG RD - Although all of the individual study location comprehension levels for this abbreviation as *frontage road* were less than 85 percent, the comprehension levels in Dallas, Fort Worth, and Austin were not statistically different from 85 percent. No explanation for these differences can be determined.

EX 30 - This abbreviation for *Exit 30* was understood by 80 percent of the 300 study participants. A difference in the comprehension level was noticed for the San Antonio participants. For this city, the abbreviation was understood at 88 percent. However, Dallas, Houston, and El Paso could not be considered statistically less than 85 percent.

RD WK - This abbreviation for *road work* was understood by only 81 percent of the 300 study participants. However, it was found that the abbreviation *RD WK* was understood above the 85 percent criterion in both Fort Worth and Austin where the abbreviation had comprehension levels of 88 and 86 percent, respectively. Also, the comprehension levels in Dallas, Houston, and San Antonio were not statistically different than 85 percent. In El Paso where understanding of *RD WK* was statistically less than 85 percent, 69 percent of the misinterpretations were made by lower education level participants (e.g., no high school diploma or a high school diploma with no college).

WORDS/PHRASES TESTED WITH ABBREVIATION ALTERNATIVES AT EACH LOCATION

As outlined in the Human Factors Study Design chapter, four of the selected words/phrases were tested using two abbreviation alternatives at each study location. Table 13 shows these words/phrases, along with the participant comprehension levels for each of the tested alternatives. When an abbreviation was not understood by 85 percent or more of the participants, common interpretations are shown.

Table 13. Words/Phrases Tested at Each Study Location with Multiple Abbreviation Alternatives.

Original Word/Phrase	Abbreviation	Locations Where Studied	Percentage of Participants Understanding Abbreviation	Other Common Interpretations (%)
Detour Route	DETOUR RTE	All 6 locations	86 (n=152)	Detour Right (20)
	DETOUR RT	All 6 locations	72 (n=148)	
Incident at	INCID AT	All 6 locations	58 (n=152)	Did not know (36)
	INCDT AT	All 6 locations	52 (n=148)	Did not know (35)
Lower Level	LWR LEVEL	All 6 locations	94 (n=148)	
	LOWER LVL	Austin, Houston, San Antonio	90 (n=77)	
	LOWR LVL	El Paso, Dallas, Ft. Worth	88 (n=75)	
Upper Level	UPR LEVEL	All 6 locations	95 (n=148)	
	UPPER LVL	Austin, Houston, San Antonio	94 (n=77)	
	UPPR LVL	El Paso, Dallas, Ft. Worth	91 (n=75)	

The following paragraphs contain a discussion for the comprehension levels of the word/phrase alternatives in Table 13 as well as indicating some study location differences identified for the abbreviations.

Detour Route - The abbreviation for *Detour Route* was presented in two different forms during this study: *DETOUR RT* and *DETOUR RTE*. The results of the study showed that when *route* was abbreviated as *RTE*, the comprehension level was 86 percent. On the other hand, using *RT* resulted in a comprehension level of only 72 percent, which is statistically different from 85 percent. Upon

further examination, it was found that the abbreviation *RT* was incorrectly interpreted as *right* by 20 percent of the participants as compared with only 7 percent of participants for *RTE*.

Incident At - For both of the abbreviation alternatives tested for the phrase *Incident At*, *INCID AT* and *INCDT AT*, the comprehension levels were only 58 and 52 percent, respectively. It should be noted that participants gave the response *do not know* 36 and 35 percent of the time, respectively, when asked to interpret the abbreviation.

Lower Level - The three abbreviation variations tested for this phrase, *LWR LEVEL*, *LOWER LVL*, and *LOWR LVL*, were understood at percentages greater than 85 percent. For the abbreviation alternative *LOWR LVL*, there was some discrepancy among the results for the different study locations. When this abbreviation was given in El Paso, only 80 percent of the participants understood the abbreviation. However, this was not statistically different from 85 percent; whereas, when it was studied in Dallas and Fort Worth, it was understood by 96 and 88 percent of the participants, respectively. Also, it was found that there were no statistical differences among the study locations.

Upper Level - For upper level, the three variations of the phrase abbreviation, *UPR LEVEL*, *UPPER LVL*, and *UPPR LVL*, had comprehension levels greater than 85 percent. This was also true for each of the individual study locations for each of the alternatives.

A PORTION OF THE PHRASE ALTERED BY STUDY LOCATION

As mentioned in the Human Factors Study Design chapter, some of the words/phrases were tested by changing a portion of the abbreviation phrase by study location in order to determine if the abbreviations would be appropriate for use in several different phrase forms. Table 14 shows the comprehension level results for these phrases. For the abbreviations that had comprehension levels less than 85 percent, other common interpretations given by the study participants are provided. The study locations where each was tested can be found in Table 10 in the Human Factors Study Design chapter. The confidence interval test using the 85 percent criterion creates the following confidence intervals for the given number of participants interpreting the abbreviation: ± 4 percent when $n = 300$, ± 6 percent when $n = 150$, ± 7 percent when $n = 100$, and ± 10 percent when $n = 50$.

The following paragraphs contain a discussion for the comprehension levels of the word/phrase alternatives in Table 14.

BLVD - For the two alternatives that were tested for the abbreviation of *boulevard*, *KING BLVD* and *PENN BLVD*, both of the phrases were understood by 93 and 96 percent of the participants, respectively.

LN - The phrases that contained this abbreviation for *lane* were, *CTR LN*, *LFT LN*, and *RGT LN*. Each of these phrases were understood by 78, 100, and 86 percent of the participants, respectively.

Table 14. Word/Phrase Abbreviation Alternatives Tested by Study Location.

Word For Abbreviation	Phrase	Abbreviation	Percentage Understanding Abbreviation	Other Common Interpretations (%)
Boulevard	<i>king</i> BOULEVARD <i>penn</i> BOULEVARD	KING BLVD PENN BLVD	93 (n=150) 96 (n=150)	
Lane	CENTER LANE LEFT LANE RIGHT LANE	CTR LN LFT LN RGT LN	78* (n=100) 100 (n=100) 86 (n=100)	did not know (8)
Interstate	INTERSTATE 20 INTERSTATE 35	IH-20 I-35	85 (n=150) 91 (n=300)	
Eastbound Northbound Southbound	EASTBOUND <i>traffic</i> NORTHBOUND <i>traffic</i> SOUTHBOUND <i>traffic</i>	EB TRAFFIC NB TRAFFIC SB TRAFFIC	10 (n=50) 30 (n=50) 10 (n=50)	did not know (72) ebbing traffic (6) did not know (50) did not know (64) sub traffic (10)
Eastbound Northbound Southbound	<i>US 180</i> EASTBOUND <i>US 75</i> NORTHBOUND <i>US 75</i> SOUTHBOUND	US180 EB US 75 NB US 75 SB	32 (n=50) 68 (n=50) 18 (n=50)	did not know (30) US 75 Nearby (6) did not know (34)

* Based on a confidence interval test, these were not statistically different than 85 percent at α equal 0.05.

Interstate - When the abbreviation *IH-20* was tested for *interstate*, the comprehension level was found to be 85 percent. When the abbreviation *I-35* was tested for *interstate*, it was understood by 91 percent of the study participants. It should be noted that *IH-20* was added to the study after data collection had begun as an alternative abbreviation and was interpreted by 150 of the participants, while *I-35* was interpreted by all 300 participants.

NB, SB, or EB - Finally, when these abbreviations were tested for *northbound*, *southbound*, and *eastbound*, the comprehension levels were found to be very low. For all of the tested alternatives, the best understood alternative was *US 75 NB* which was studied in Dallas where 68 percent of the participants correctly interpreted the abbreviation. Only between 10 and 32 percent correctly interpreted the abbreviation in the other cities.

INTERPRETATION OF PHRASES WITH MORE THAN ONE ABBREVIATION

When phrases were tested that contained more than one abbreviation, some participants were able to correctly interpret only one of the abbreviations in the phrase. Individual abbreviations, such as *LN* from the phrase *LFT LN*, that were interpreted correctly by 85 percent or more of the participants are shown in Table 15. The word abbreviations given in this table were tested in specific phrases, and the level of driver comprehension in other phrases cannot be estimated from these results.

For most of the abbreviations contained in Table 15, the results were consistent for each of the phrases that were tested using an individual abbreviation. For the abbreviations *CTR* in the phrase *CTR LN*, *LN* in the phrase *CTR LN*, and *MAJ* in *MAJ CONG*, the comprehension levels were below 85 percent but could not be considered statistically different from 85 percent. Also, several of the abbreviations did have study location differences that were less than 85 percent, but none were found to be statistically different from 85 percent.

Table 16 shows individual abbreviations understood by less than 85 percent of the participants. It should be noted that at certain individual study locations, the abbreviations were understood at a level greater than 85 percent; these locations are shaded in the table.

Table 15. Individual Abbreviations Understood by Greater Than 85 Percent of Study Participants.

Word	Message Phrase	Abbreviation for Word	Comprehension Percentages						Total
			Dallas n=50	Fort Worth n=50	Houston n=50	El Paso n=50	Austin n=50	San Antonio n=50	
Access	ACCES RD	ACCES	96	94	96	90	96	96	95 (n=300)
Accident	MAJ ACCDT	ACCDT	98	98	96	88	94	94	95 (n=300)
	MNR ACCDT	ACCDT	100	98	94	94	92	90	95 (n=300)
Blocked	FWY BLKD	BLKD	90	92	92	88	78*	84*	87 (n=300)
Center	CTR LN	CTR			82*	78*			80* (n=100)
Closed	LN CLSD	CLSD	100	98	96	94	98	92	96 (n=300)
Emergency	EMER VEH	EMER	96	98	90	92	98	92	94 (n=300)
Freeway	FWY BLKD	FWY	96	98	98	94	82*	94	94 (n=300)
Lane	LFT LN	LN	100				100		100 (n=100)
	RGT LN	LN		94				86	94 (n=100)
	CTR LN	LN			82*	84*			83* (n=100)
	LN CLSD	LN	98	100	98	86	92	90	90 (n=100)
Left	LFT LN	LFT	100				100		100 (n=100)
Level	UPPR LVL	LVL	92	92		88			91 (n=75)
	LOWR LVL	LVL	96	88		84*			89 (n=75)
Lower	LOWR LVL	LOWR	96	96		92			95 (n=75)
Major	MAJ ACCDT	MAJ	100	98	96	94	96	100	97 (n=300)
	MAJ CONG	MAJ	84*	86	82*	80*	80*	86	83* (n=300)
Minor	MNR ACCDT	MNR	92	90	88	94	82*	92	95 (n=300)
Right	RGT LN	RGT		92				86	89 (n=100)
Road	ACCES RD	RD	100	100	100	100	98	100	100 (n=300)
	SERV RD	RD	100	98	100	96	96	100	98 (n=300)
	RD WK	RD	100	96	96	100	94	98	97 (n=300)
	FEED RD	RD	98	98	100	94	92	92	96 (n=300)
	FRNTG RD	RD	94	96	96	80*	92	82*	90 (n=300)
Service	SERV RD	SERV	98	98	96	92	92	88	94 (n=300)
Traffic	TRAF CLR	TRAF	98	98	100	100	98	96	98 (n=300)
Upper	UPPR LVL	UPPR	92	96		92			93 (n=75)
Vehicle	EMER VEH	VEH	96	98	90	92	98	92	94 (n=300)

* Based on a confidence interval test, these were not statistically different than 85 percent at α equals 0.05.

Table 16. Individual Abbreviations Understood by Less Than 85 Percent of Study Participants.

Word	Message Phrase	Abbreviation for Word	Comprehension Percentages							Other Common Interpretations
			Dallas n=50	Fort Worth n=50	Houston n=50	El Paso n=50	Austin n=50	San Antonio n=50	Total n = 300	
Alternate	ALT RTS	ALT	86	86	74	66	70	78*	77	alter
Clear	TRAF CLR	CLR	84*	74	78*	70	78*	81*	78	circle
Congestion	MAJ CONG	CONG	54	60	38	62	48	60	54	construction
Feeder	FEED RD	FEED	38	42	72	8	46	42	41	feed
Frontage	FRNTG RD	FRNTG	80*	76*	74	48	78*	62	70	front
Routes	ALT RTS	RTS	86	90	74	64	64	88	78	right
Work	RD WK	WK	76*	88	80*	74	86	80*	81	walk

* Not statistically different from 85 percent using the confidence interval test with α equals 0.05.

Note: Shading indicates comprehension percentages that were greater than 85 percent.

The following paragraphs contain discussion regarding differences that were detected in Table 16 for study location comprehension levels.

ALT - This abbreviation for *alternate* used in the phrase *ALT RTS* was understood overall by only 77 percent of the study participants, but in both Dallas and Fort Worth, it was understood by 86 percent of the participants. Also, in San Antonio, it had a comprehension level of 78 percent which cannot be considered statistically different from 85 percent. No explanation for these study location differences can be determined.

CLR - This abbreviation for *clear* was understood overall by 78 percent of the participants and was considered to be statistically different from 85 percent. When the individual study locations were tested, the comprehension levels in Dallas (84 percent), Houston (78 percent), Austin (78 percent), and San Antonio (81 percent) could not be considered statistically different from 85 percent.

FRNTG - This abbreviation for *frontage* was understood by 70 percent of the overall study participants. Although none of the individual study locations had comprehension levels greater than 85 percent, it was determined that the comprehension levels in Dallas (80 percent), Fort Worth (76 percent), and Austin (78 percent) could not be considered statistically less than 85 percent.

RTS - The abbreviation for *routes* was understood overall by 78 percent of the participants but was statistically different from 85 percent. However, at Dallas, Fort Worth, and San Antonio, it was understood by 86, 90, and 88 percent of the participants, respectively. The study location differences cannot be explained at this time.

WK - This abbreviation for *work* was presented as part of the phrase *RD WK*. The abbreviation was understood by only 81 percent of the study participants, which is statistically less than 85 percent. In Fort Worth and Austin, it was understood by 88 and 86 percent of the participants, respectively. Also, the comprehension levels in Dallas (76 percent), Houston (80 percent), and San Antonio (80 percent) were not statistically different than 85 percent.

COMPARISON OF RESULTS TO PREVIOUS RESEARCH

A comparison was made between the current study results and the results of the previous abbreviation studies conducted in Texas by Huchingson and Dudek in 1983 and by Hustad and Dudek in 1997 to determine if consistent results had been obtained from the current and previous two abbreviation studies. Words/phrases were compared when the exact abbreviation was tested in both the current study and one or more of the previous studies. Table 17 contains the comprehension percentages for the abbreviations that were tested in two or more of the studies. The words/phrases that were found to have significant comprehension percentage differences between the three studies were: *alternate routes*, *center lane*, *construction*, *interstate*, *interchange*, and *road work*.

From Table 17, there are several abbreviation words/phrases that were studied in Texas which had differences between the current study comprehension percentages and the previous studies' comprehension percentages. The differences may be accounted for by the fact that the earlier studies did not specify the need for a demographic sample of the driving population. Therefore, based on previous research, it can be assumed that if particular demographics were not sought after, the greatest percentage of the participants would have high education levels, i.e. some college or a college degree. Whereas for the current study demographics, which are based on the actual driving population statistics, 58 percent of the drivers had lower education levels, i.e. no high school diploma or a high school diploma with no college. The lower education sample explains the reason for the lower comprehension levels obtained for many of the abbreviations in the current sample.

Another factor that may contribute to the differences between the abbreviations studies is that the current study was conducted at six different Texas locations, whereas the previous studies had been conducted in only a single location. In the current study, it was observed that in the San Antonio and El Paso areas there was a problem that, although participants met the established criteria for the study, there was a significant portion of the participants who did not speak English as their primary language. The previous studies were conducted in Bryan/College Station, Texas, and in Dallas, Texas, where the problems with language were not observed during the administration of the current study. Again, this inconsistency in the study methods may have contributed to the comprehension level differences noted between the studies.

Table 17. Comparison of Texas Abbreviation Study Results: 1983, 1997, and Current.

Word/Phrase	Abbreviation	Comprehension Percentages		
		1983 Study	1997 Study	Current Study
alternate routes	ALT RTS	N/A	86	72
[name] bridge	[name] BRDG	96	95	87
[name] boulevard	[name]BLVD	96	N/A	95
center lane	CTR LN	N/A	88	78*
construction	CONST	76	95	85
emergency vehicle	EMER VEH	N/A	93	92
exit [number]	EX [number]	N/A	81	80
fog ahead	FOG AHD	100	N/A	90
interchange [number]	INTCH [number]	N/A	77	32
interstate - [number]	I-[number]	92	95	81
left lane	LFT LN	N/A	90	100
[number] miles	[number] MI	100	N/A	94
on shoulder	ON SHLDR	N/A	95	93
prepare to stop	PREP TO STOP	100	N/A	97
road work	RD WK	N/A	95	81
right lane	RGT LN	N/A	100	86
truck stop	TRK STOP	N/A	91	86
wet pavement	WET PVMT	100	N/A	95
weight limit	WT LIMIT	N/A	95	89

* Not statistically different from 85 percent using the confidence interval test with α equals 0.05.
 N/A: Data not available.

DESCRIPTORS FOR THE ROADWAY ADJACENT TO FREEWAYS

Different designations can be given when addressing the roadway that runs adjacent to many freeways in Texas. A comparison was made of the comprehension levels for each of the following phrase abbreviations that could be used for this purpose in order to determine which were best understood by drivers:

- access road,
- feeder road,
- frontage road, and
- service road.

Each of these phrases was tested in the abbreviation study for participant understanding and was interpreted by all 300 of the study participants. The abbreviation comprehension levels are given by study location in Table 18.

Table 18. Comprehension Levels for Abbreviations of Descriptors for the Roadway Adjacent to Freeways in Texas.

Phrase	Abbreviation	Percentage of Participants Understanding Abbreviation						
		Dallas n=50	Ft. Worth n=50	Houston n=50	El Paso n=50	Austin n=50	San Antonio n=50	Total n=300
Access Road	ACCES RD	96	94	96	90	96	96	95
Feeder Road	FEED RD	38	40	72	8	46	40	41
Frontage Road	FRNTG RD	80*	76*	74	48	78*	62	70
Service Road	SERV RD	98	96	96	90	90	88	93

* Not statistically less than 85 percent using the confidence interval test at α equals 0.05.

Table 18 shows that the phrase abbreviations for *Access Road* and *Service Road* had comprehension levels of 95 and 93 percent, respectively, for the total sample of 300 drivers. Also, it can be seen that both had comprehension levels greater than 85 percent at all of the individual study locations. In contrast, the abbreviations for *Frontage Road* and *Feeder Road* had overall comprehension levels of 70 and 41 percent, respectively. It is also shown that the comprehension levels for these two descriptors at each individual study locations were less than 85 percent. However, the comprehension level for the *Frontage Road* abbreviation was not statistically less than 85 percent at Dallas (80 percent), Fort Worth (76 percent), and Austin (78 percent). No other study location differences were noted for the descriptors.

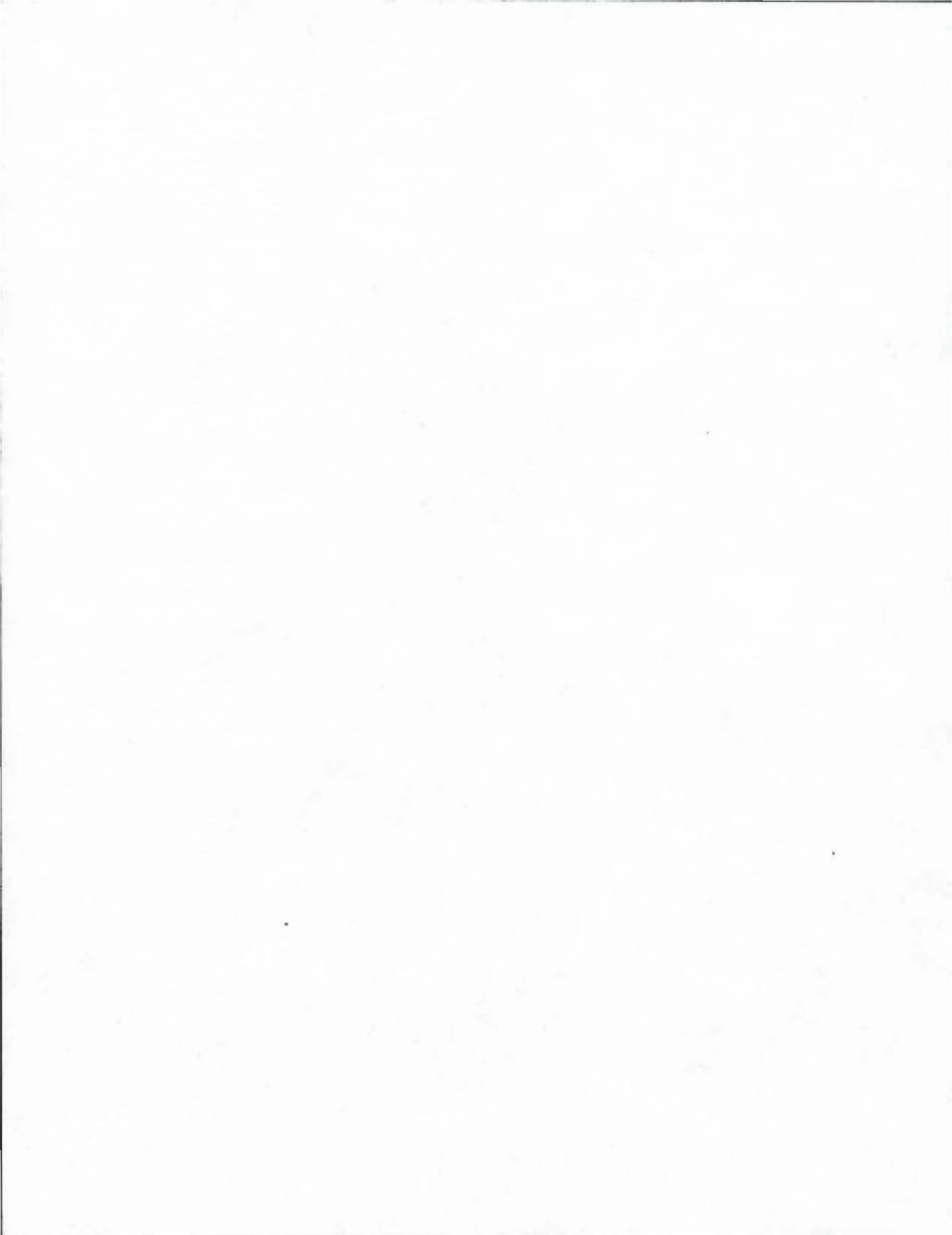
The results shown in Table 18 were compared with the information given in Table 19, which shows the responses given by participants when asked the following question: "A roadway is located next to some freeways in [city name]. What do you normally call this roadway?"

The shaded areas in Table 19 show the largest percentage of responses for each study location. From Table 19, there was not a single descriptor that was selected by 85 percent or more of the driver subjects in the city. The most common descriptor selected in each city was *Service Road* in Dallas (52 percent), *Service Road* in Fort Worth (44 percent), *Feeder Road* in Houston (72 percent), *Gateway* in El Paso (32 percent), *Access Road* in Austin (30 percent), and *Access Road* in San Antonio (64 percent). The results indicate that currently, it may be difficult designing messages when this roadway must be identified on the DMS.

Table 19. Labels for the Roadway Adjacent to Interstates or Highways in Texas.

Adjacent Road Name	Study Location Response Percentages						Total Percent
	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	
Access Road	18	26	2	20	30	64	27
Feeder Road	8	0	72	0	12	6	16
Frontage Road	12	16	8	4	18	6	11
Service Road	52	44	6	4	14	8	21
Side Road	6	2	0	8	10	6	5
Gateway	0	0	0	32	0	0	5
Other Responses	4	12	12	32	16	10	15

Note: Shading indicates the largest percentage of responses for each study location.



5. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The primary concern with using abbreviations is that the driver must be able to interpret the information being provided. Human factors studies were conducted in Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio to evaluate driver understanding of abbreviations that would typically be used on DMSs in Texas. The abbreviations were considered understood when 85 percent or more of the participants were able to interpret the given abbreviation as the word/phrase that was intended by the researchers. The abbreviations that met this criterion are recommended for use in DMS messages in Texas.

RECOMMENDATIONS

Acceptable Abbreviations for Statewide Use in Texas

Table 20 contains the abbreviations for which 85 percent or more of the driver subjects in the six cities combined (Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio) understood the abbreviation. The number of participants who interpreted each abbreviation was 300, unless specified otherwise in the table.

Acceptable Abbreviations in Specific Texas Cities Which Should Either Be Used with Caution or Should Not Be Used in Other Cities

A group of abbreviations were found to be well understood in some of the six Texas cities studied, but they were found to be understood by less than 85 driver subjects in other cities. However, the percentages were found not to be statistically different from 85 percent. These abbreviations, shown in Table 21, are acceptable in the cities with 85 or higher comprehension levels but should be used with caution in the other cities. Additional drivers should be studied to increase the sample size before a more definitive recommendation can be made for these latter cities. However, there are some abbreviations that were not acceptable in some of the cities.

Abbreviations That Should Not Be Used in Texas

Table 22 contains a list of abbreviations that should not be used in Texas. Alternative abbreviations or words are given for these abbreviations for which less than 85 percent of the drivers in the study understood.

Table 20. Acceptable Abbreviations for Statewide Use in Texas.

Original Word/Phrase	Abbreviation	Percentage of Participants Understanding Abbreviation . (n=300)
2 miles	[number] MI	94
15 minute delay	[number] MIN DELAY	95
access road	ACCES RD	95
King [Penn] Boulevard	[name] BLVD	93 (n=150),[96 (n=150)]
detour route	DETOUR RTE	86 (n=151)
emergency vehicle	EMER VEH	92
fog ahead	FOG AHD	90
Hempstead Highway	[name] HWY	94
interstate 35	I-35	91
interstate highway 20	IH-20	85
lane closed	LN CLSD	93
left lane	LFT LN	100 (n=100)
lower level	LWR LEVEL LOWER LVL LOWR LVL	94 (n=148) 90 (n=77) 88 (n=75)
major accident	MAJ ACCDT	94
on shoulder	ON SHLDR	93
oversize load	OVSZ LOAD	90
parking lot	PRK LOT	96
prepare to stop	PREP TO STOP	97
right lane	RGT LN	86 (n=100)
service road	SERV RD	93
to downtown	TO DWNTN	92
upper level	UPR LEVEL UPPER LVL UPPR LVL	95 (n=148) 94 (n=77) 91 (n=75)
weight limit	WT LIMIT	89
wet pavement	WET PVMT	95

Table 21. Acceptable Abbreviations for Certain Texas Cities but Should Either Be Used with Caution or Should Not Be Used in Other Cities.

Original Word/Phrase	Abbreviation	Comprehension Percentages						
		Dallas n=50	Fort Worth n=50	Houston n=50	El Paso n=50	Austin n=50	San Antonio n=50	Total n = 300
accident at	ACCDT AT	96	96	86	90	84*	78*	88
Beltway 2	BLTWY [number]	74	58	98	22	58	48	60
construction	CONST	92	90	76*	86	86	80*	85
Exit 30	EX [number]	78*	72	84*	82*	74	88	80
expressway closed	EXPWY CLOSED	92	94	88	64	82*	90	85
freeway blocked	FWY BLKD	88	92	92	88	74	84*	86
fog ahead	FOG AHD	90	94	84*	84*	94	92	90
Mason Bridge	MASON BRDG	88	82*	90	84*	88	90	87
major accident	MAJ ACCDT	98	98	96	86	94	94	94
minor accident	MNR ACCDT	92	90	86	92	82*	90	89
road work	RD WK	76*	88	80*	74	86	80*	81
traffic clear	TRAF CLR	88	78*	82*	76*	80*	90	82*
truck stop	TRK STOP	82*	86	76*	92	90	92	86

* Not statistically different than 85 percent at α equal 0.05.

NOTE: Boxes that are shaded show cities in which abbreviation should be used with caution. Boxes with cross-out show cities in which abbreviation should not be used.

Table 22. Abbreviations Not Recommended for Use in Texas.

Word/Phrase	Abbreviation	Percentage of Participants Understanding Abbreviation (n=300)	Recommended Alternatives
Alternate Route	ALT RT	72	OTHER RTE
Detour Route	DETOUR RT	72 (n=148)	DETOUR RTE
Feeder Road	FEED RD	41	FEEDER RD
Frontage Road	FRNTG RD	70	FRONTAGE RD
High Occupancy Vehicle Lane	HOV LANE	21	investigate other terms
Interchange 14	INTCH 14	32	use full word: INTERCHANGE 14
Incident at	INCDT AT INCID AT	52 (n=148) 58 (n=152)	ACCDT AT ACCDT AT
Major Congestion	MAJ CONG	53	MAJ CONGESTION
Road Work	RD WK	80	ROADWORK
Vicinity of	VIC OF	16	NEAR
Northbound traffic	NB TRAFFIC	30 (n=50)	<i>[route]</i> N
US 75 Northbound	<i>[route]</i> NB	68 (n=50)	<i>[route]</i> N
Eastbound Traffic	EB TRAFFIC	10 (n=50)	<i>[route]</i> E
US 180 Eastbound	<i>[route]</i> EB	32 (n=50)	<i>[route]</i> E
Southbound Traffic	SB TRAFFIC	10 (n=50)	<i>[route]</i> S
US 75 Southbound	<i>[route]</i> SB	18 (n=50)	<i>[route]</i> S

6. REFERENCES

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- 36. MASON BRDG _____
- 37. EMER VEH _____
- 38. HOV LANE _____
- 39. MNR ACCDT _____
- 40. PREP TO STOP _____
- 41. VIC OF _____
- 42. KING BLVD _____
- 43. EX 30 _____
- 44. INCDT AT _____
- 45. EB TRAFFIC _____
- 46. DETOUR RT _____
- 47. WT LIMIT _____

That completes the survey. Thank you for your time!

[Study Location] 2 - 1999

Participant # _____

This survey is being conducted by the Texas Transportation Institute (TTI), which is part of the Texas A&M University System. It is sponsored by the Texas Department of Transportation. The purpose of this survey is to determine drivers' understanding of abbreviations used on highway signs. Your response will be completely confidential and will be used for statistical purposes only.

The following is a list of abbreviations that could appear on highway signs. Please print the word or series of words that you believe are being abbreviated in the blank following the abbreviation.

<i>EXAMPLE: SIDE ST</i>	<i>Side Street</i>
1. WT LIMIT	_____
2. INCDT AT	_____
3. VIC OF	_____
4. HOV LANE	_____
5. UPR LEVEL	_____
6. MAJ ACCDT	_____
7. BLTWY 2	_____
8. ACCES RD	_____
9. ALT RTS	_____
10. LN CLSD	_____
11. FOG AHD	_____
12. 2 MI	_____
13. CONST	_____
14. INTCH 14	_____
15. ACCDT AT	_____
16. EX 30	_____
17. MNR ACCDT	_____
18. WET PVMT	_____
19. LWR LEVEL	_____
20. EMER VEH	_____
21. TRAF CLR	_____
22. LFT LN	_____
23. I-35	_____
24. OVSZ LOAD	_____
25. DETOUR RT	_____
26. PREP TO STOP	_____
27. TO DWNTN	_____
28. RD WK	_____
29. ON SHLDR	_____
30. SERV RD	_____
31. EB TRAFFIC	_____
32. HEMPSTEAD HWY	_____

- 33. 15 MIN DELAY _____
- 34. FEED RD _____
- 35. KING BLVD _____
- 36. FRNTG RD _____
- 37. EXPWY CLOSED _____
- 38. PRK LOT _____
- 39. MAJ CONG _____
- 40. TRK STOP _____
- 41. MASON BRDG _____
- 42. FWY BLKD _____

That completes the survey. Thank you for your time!

[Study Location] 3 - 1999

Participant # _____

This survey is being conducted by the Texas Transportation Institute (TTI), which is part of the Texas A&M University System. It is sponsored by the Texas Department of Transportation. The purpose of this survey is to determine drivers' understanding of abbreviations used on highway signs. Your response will be completely confidential and will be used for statistical purposes only.

The following is a list of abbreviations that could appear on highway signs. Please print the word or series of words that you believe are being abbreviated in the blank following the abbreviation.

<i>EXAMPLE: SIDE ST</i>	<i>Side Street</i>
1. TRK STOP	_____
2. LFT LN	_____
3. TRAF CLR	_____
4. LOWER LVL	_____
5. TO DWNTN	_____
6. EX 30	_____
7. HOV LANE	_____
8. VIC OF	_____
9. EB TRAFFIC	_____
10. MAJ CONG	_____
11. SERV RD	_____
12. 2 MI	_____
13. FWY BLKD	_____
14. RD WK	_____
15. ACCES RD	_____
16. MAJ ACCDT	_____
17. EMER VEH	_____
18. KING BLVD	_____
19. DETOUR RTE	_____
20. EXPWY CLOSED	_____
21. CONST	_____
22. 15 MIN DELAY	_____
23. BLTWY 2	_____
24. MNR ACCDT	_____
25. INCID AT	_____
26. INTCH 14	_____
27. ACCDT AT	_____
28. FRNTG RD	_____
29. MASON BRDG	_____
30. FOG AHD	_____
31. LN CLSD	_____
32. WET PVMT	_____

- 33. OVSZ LOAD _____
- 34. PRK LOT _____
- 35. WT LIMIT _____
- 36. HEMPSTEAD HWY _____
- 37. FEED RD _____
- 38. ALT RTS _____
- 39. PREP TO STOP _____
- 40. I-35 _____
- 41. UPPER LVL _____
- 42. ON SHLDR _____

That completes the survey. Thank you for your time!

[Study Location] 4 - 1999

Participant # _____

This survey is being conducted by the Texas Transportation Institute (TTI), which is part of the Texas A&M University System. It is sponsored by the Texas Department of Transportation. The purpose of this survey is to determine drivers' understanding of abbreviations used on highway signs. Your response will be completely confidential and will be used for statistical purposes only.

The following is a list of abbreviations that could appear on highway signs. Please print the word or series of words that you believe are being abbreviated in the blank following the abbreviation.

- EXAMPLE: SIDE ST* _____ *Side Street*
1. LOWER LVL _____
 2. MASON BRDG _____
 3. EB TRAFFIC _____
 4. CONST _____
 5. LN CLSD _____
 6. TO DWNTN _____
 7. VIC OF _____
 8. INTCH 14 _____
 9. LFT LN _____
 10. BLTWY 2 _____
 11. EX 30 _____
 12. FEED RD _____
 13. ALT RTS _____
 14. EMER VEH _____
 15. MAJ CONG _____
 16. FWY BLKD _____
 17. WET PVMT _____
 18. ACCDT AT _____
 19. 15 MIN DELAY _____
 20. HOV LANE _____
 21. DETOUR RTE _____
 22. I-35 _____
 23. TRAF CLR _____
 24. HEMPSTEAD HWY _____
 25. KING BLVD _____
 26. SERV RD _____
 27. RD WK _____
 28. UPPER LVL _____
 29. EXPWY CLOSED _____
 30. FOG AHD _____
 31. MNR ACCDT _____
 32. 2 MI _____

- 33. ACCES RD _____
- 34. TRK STOP _____
- 35. PRK LOT _____
- 36. OVSZ LOAD _____
- 37. MAJ ACCDT _____
- 38. ON SHLDR _____
- 39. WT LIMIT _____
- 40. INCID AT _____
- 41. FRNTG RD _____
- 42. PREP TO STOP _____

That completes the survey. Thank you for your time!

APPENDIX B
STUDY RESULTS
Table B-1. Study Results.

2 MI	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
2 miles	47	48	47	48	45	48	283	94
2 miles per hour	1	1	1	1	3		7	2
2 miles ahead			1	1		1	3	1
Other Responses (4 groups)	2	1	1		2	1	7	2
Total Correct Responses	47	48	47	48	45	48	283	94
% Correct Responses	94	96	94	96	90	96		
15 MIN DELAY								
15 minute delay	49	47	48	46	45	49	284	95
did not know		3		2	2		7	2
15 miles delay					2		2	1
Other Responses (5 groups)	1		2	2	1	1	7	2
Total Correct Responses	49	47	48	46	45	49	284	95
% Correct Responses	98	94	96	92	90	98		

B-1 (continued).

ACCDT AT	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
accident at	45	45	42	33	34	30	229	76
accident ahead	3			3	8	4	18	6
accident		2	1	6		3	12	4
accident attention				1		2	3	1
accident alternate		1					1	0.3
accident at risk				1			1	0.3
accident attended				1			1	0.3
did not know	2	2	7	3	8	7	29	10
other responses (6 groups)				2		4	6	2
Total Correct Responses	48	48	43	45	42	39	265	88
% Correct Responses	96	96	86	90	84	78		
ALT RTS								
alternate routes	41	42	26	30	21	38	198	66
alternate route			5		11		16	5
alternative routes			2				2	1
did not know	3	3	6	13	11		36	12
alter routes	2	2	3			6	13	4
alternate right	1	1		3		1	6	2
alternate roads			2		2		4	1
alter right	2		1	1			4	1
alternate ?	1		2				3	1
altitude routes				2			2	1
other responses (15 groups)		2	3	1	5	5	16	5
Total Correct Responses	41	42	33	30	32	38	216	72
% Correct Responses	82	84	66	60	64	76		

B-1 (continued).

ACCES RD	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
access road	48	47	48	45	48	48	284	95
access road	1	2		3			6	2
other responses (9 groups)	1	1	2	2	2	2	10	3
Total Correct Responses	48	47	48	45	48	48	284	95
% Correct Responses	96	94	96	90	96	96		
BLTWY 2								
beltway 2	37	39	49	11	29	24	179	60
did not know	12	16	1	30	15	18	92	31
blockway 2		2			1	1	4	1
blocked 2 way	1	1			1		3	1
? way 2				1		1	2	1
boulevard highway 2				2			2	1
other responses (18 groups)		2		6	4	6	18	6
Total Correct Responses	37	29	49	11	29	24	179	60
% Correct Responses	74	58	98	22	58	48		
KING BLVD								
King Boulevard			48		44	44	136	91
ML King Boulevard			1		2		3	2
Kingwood Boulevard			1				1	1
did not know					4	3	7	5
other responses (3 groups)						3	3	2
Total Correct Responses			50		46	44	140	93
% Correct Responses			100		92	88		

B-1 (continued).

PENN BLVD	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
Pennsylvania Boulevard	30	24		21			75	50
Penn Boulevard	20	23		21			64	43
Penninsula Boulevard		1					1	1
? Boulevard				2			2	1
Pennsylvania State Boulevard				1			1	1
Penatentury Boulevard				1			1	1
did not know		2		4			6	4
Total Correct Responses	50	48		46			144	96
% Correct Responses	100	96		92				
CTR LN								
center lane			39	39			78	78
did not know			3	5			8	8
? lane			4	1			5	5
Other Responses (9 groups)			4	5			9	9
Total Correct Responses			39	39			78	78
% Correct Responses			78	78				
CONST								
construction	46	45	38	42	43	40	254	85
construction ahead				1			1	1
constant	2			3		2	7	2
did not know	2	4	7	2	6	4	25	8
other responses (12 groups)		1	5	2	1	4	13	4
Total Correct Responses	46	45	38	43	43	40	255	85
% Correct Responses	92	90	76	86	86	80		

B-1 (continued).

DETOUR RT	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
detour route	18	17	20	18	18	16	107	72
detour right	6	8	2	4	1	8	29	20
did not know	1		1	2	1	1	6	4
other responses (6 groups)			1	1	4		6	4
Total Correct Responses	18	17	20	18	18	16	107	72
% Correct Responses	72	68	83	72	72	64		
DETOUR RTE								
detour route	23	22	21	21	22	22	131	86
detour right	2	1	3	2	1	1	10	7
did not know		1	2	1	1	1	6	4
other responses (5 groups)		1		1	2	1	5	3
Total Correct Responses	23	22	21	21	22	22	131	86
% Correct Responses	92	88	81	84	85	88		
EXPWY CLOSED								
expressway closed	46	47	44	32	41	45	255	85
express closed	2	1	3		3	1	10	3
express highway closed		1		1	2	1	5	1
exit highway closed				4			4	1
did not know	1	1		6	1	1	10	3
other responses (12 groups)	1		3	7	3	2	16	5
Total Correct Responses	46	47	44	32	41	45	255	85
% Correct Responses	92	94	88	64	82	90		

B-1 (continued).

EMER VEH	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
emergency vehicle	48	48	43	46	48	44	277	92
emergency ?			1	3		1	5	2
did not know	2	1	4	1		2	10	3
other responses (6 groups)		1	2		2	3	8	3
Total Correct Responses	48	48	43	46	48	44	277	92
% Correct Responses	96	96	86	92	96	88		
EX 30								
exit 30	39	36	42	41	37	44	239	80
expressway 30	4	3	1		2	2	12	4
express 30	1	2	1		1		5	2
extension 30	1	2		3	2		8	3
exchange 30		3	1				4	1
exit 30 mph		1			1	2	4	1
exit 30 miles			3				3	1
did not know	4	3	2	4	3		16	5
other responses (9 groups)	1			2	4	2	9	3
Total Correct Responses	39	36	42	41	37	44	239	80
% Correct Responses	78	72	84	82	74	88		
FEED RD								
feeder road	19	20	36	4	23	20	122	41
feed road	30	29	13	41	18	26	157	52
did not know				2	4	3	9	3
? road				1	2		3	1
other responses (7 groups)	1	1	1	2	3	1	9	3
Total Correct Responses	19	20	36	4	23	20	122	41
% Correct Responses	38	40	72	8	46	40		

B-1 (continued).

FOG AHD	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
fog ahead	45	47	42	42	47	46	269	90
foggy ahead	2						2	1
did not know	3	3	7	7	2	2	24	8
other responses (3 groups)			1	1		2	4	1
Total Correct Responses	45	47	42	42	47	46	269	90
% Correct Responses	90	94	84	84	94	92		
FWY BLKD								
freeway blocked	44	46	46	44	37	42	259	86
freeway ?	2	1	1	1	3	2	10	3
freeway blockade	2		1			1	4	1
freeway boulevard		1		1	1	2	5	2
did not know	1		1	2	7	2	13	4
other responses (8 groups)	1	2	1	2	2	1	9	3
Total Correct Responses	44	46	46	44	37	42	259	86
% Correct Responses	88	92	92	88	74	84		
FRNTG RD								
frontage road	40	38	37	24	39	31	209	70
front road	3	3	4	3	2	2	17	6
frontground road				2			2	1
? road	2	6	7	10	3	5	33	11
did not know	3	2	2	7	4	9	27	9
other responses (11 groups)	2	1		4	2	3	12	4
Total Correct Responses	40	38	37	24	39	31	209	70
% Correct Responses	80	76	74	48	78	62		

B-1 (continued).

HEMPSTEAD HWY	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
Hempstead Highway	50	48	50	45	43	47	283	94
did not know		1		5	6	2	14	5
other responses (3 groups)		1			1	1	3	1
Total Correct Responses	50	48	50	45	43	47	283	94
% Correct Responses	100	96	100	90	86	94		
HOV LANE								
high occupancy vehicle lane	13	18	18		7	6	62	21
high occupancy lane	4	4	2		1		11	4
high occupant lane		1					1	1
high occupied lane		1					1	1
2 or more people (concept)	18	10	6		6	1	41	14
did not know	7	6	7	42	26	30	118	39
hover lane		1	5	3	3	3	15	5
HOV lane	1	2	3		1	2	9	3
express lane	2	2					4	1
hoover lane		1		1	2		4	1
bus or transit lane			6			1	7	2
other responses (24 groups)		4	3	4	4	7	27	9
Total Correct Responses	17	24	20	0	8	6	75	25
% Correct Responses	34	48	40	0	16	12		

B-1 (continued).

I-35	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
interstate 35	39	44	42	38	36	38	237	79
interstate highway 35	1		1		3		5	2
highway 35	4	3	2	2	5	6	22	7
freeway 35	2	3		3			8	3
intersection 35	2				1	2	5	2
did not know			3	4	1		8	3
other responses (24 groups)	2		2	3	4	4	15	5
Total Correct Responses	40	44	43	38	39	38	242	81
% Correct Responses	80	88	86	76	78	76		
IH-20								
interstate highway 20	31	28		20			79	53
interstate 20	7	12		3			22	15
highway 20	9	5		9			23	15
freeway 20				3			3	2
did not know		4		9			13	9
other responses (15 groups)	3	1		6			10	7
Total Correct Responses	38	40		23			101	67
% Correct Responses	76	80		46				
INTCH 14								
interchange 14	17	26	13	11	15	14	96	32
inch 14	3	3	3	7	7	3	26	9
intersection 14	2	1	4	6	4	6	23	8
interstate		1	2	1	1		5	2
interchannel	1			2		1	4	1
did not know	24	16	26	23	19	21	129	43
other responses (15 groups)	3	3	2		4	5	17	6
Total Correct Responses	17	26	13	11	15	14	96	32
% Correct Responses	34	52	26	22	30	28		

B-1 (continued).

INCDT AT	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
incident at	14	13	14	14	11	11	77	52
incident attention				1			1	1
incident ahead						1	1	1
accident at	1	1		2		1	5	3
indicated at	1	2	1	1		1	6	4
did not know	9	8	7	7	11	10	52	35
other responses (4 groups)		1	2		2	1	6	4
Total Correct Responses	14	13	14	15	11	12	79	53
% Correct Responses	56	52	58	60	46	48		
INCDT AT								
incident at	17	18	16	11	13	13	88	58
incident attended				1			1	1
incident				2			2	1
incident ahead				1	1		2	1
did not know	8	7	8	10	12	10	55	36
accident at			1			2	3	2
indicated at			1				1	1
Total Correct Responses	17	18	16	15	14	13	93	63
% Correct Responses	68	72	62	60	54	52		
LFT LN								
left lane	50				50		100	100
Total Correct Responses	50				50		100	100
% Correct Responses	100				100			

B-1 (continued).

LN CLSD	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
lane closed	49	49	47	43	44	43	275	92
lane closure					2	1	3	1
left lane closed	1		1		1	1	4	1
did not know				3	1	3	7	2
other responses (6 groups)		1	2	4	2	2	11	4
Total Correct Responses	49	49	47	43	46	44	278	93
% Correct Responses	98	98	94	86	92	88		
LWR LEVEL								
lower level	23	24	23	23	22	24	139	94
? level		1	1	1	1		4	3
other responses (4 groups)	2			1	1	1	5	3
Total Correct Responses	23	24	23	23	22	24	139	94
% Correct Responses	92	96	96	92	92	96		
LOWR LVL								
lower level	24	22		20			66	88
lower ?		2		2			4	5
did not know	1	1		1			3	4
? level				1			1	1
lower valley				1			1	1
Total Correct Responses	24	22		20			66	88
% Correct Responses	96	88		80				
LOWER LVL								
lower level			23		24	22	69	90
lower ?			2		1	2	5	7
lower village			1				1	1
low lights					1		1	1
lower lovers lane						1	1	1
Total Correct Responses			23		24	22	69	90
% Correct Responses			88		92	88		

B-1 (continued).

MAJ CONG	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
major congestion	27	29	19	30	24	30	159	53
major congested		1					1	0.3
major construction	2	5	9	2	6	4	28	9
major conjunction	2	1	3		1		7	2
major ?	10	6	9	6	3	6	40	13
did not know	8	7	8	7	10	6	46	15
other responses (17 groups)	1	1	2	5	6	4	19	6
Total Correct Responses	27	30	19	30	24	30	160	53
% Correct Responses	54	60	38	60	48	60		
MAJ ACCDT								
major accident	49	49	48	43	47	47	283	94
did not know		1	2	1	2		6	2
other responses (7 groups)	1			6	1	3	11	4
Total Correct Responses	49	49	48	43	47	47	283	94
% Correct Responses	98	98	96	86	94	94		
MNR ACCDT								
minor accident	46	45	43	46	41	45	266	89
major accident	2	2	1		4		9	3
? accident	2		3	1			6	2
did not know		1	2	2	4	4	13	4
other responses		2	1	1	1	1	6	2
Total Correct Responses	46	45	43	46	41	45	266	89
% Correct Responses	92	90	86	92	82	90		

B-1 (continued).

MASON BRDG	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
Mason bridge	43	39	45	42	44	43	256	85
mason building	3	2	1	1	1		8	3
masonry bridge	1	2				2	5	2
did not know	3	7	3	5	4	4	26	9
other responses (5 groups)			1	2	1	1	5	2
Total Correct Responses	44	41	45	42	44	45	261	87
% Correct Responses	88	82	90	84	88	90		
ON SHLDR								
on shoulder	48	47	50	44	43	48	280	93
did not know	1	2		1	4	1	9	3
other responses (11 groups)	1	1		5	3	1	11	4
Total Correct Responses	48	47	50	44	43	48	280	93
% Correct Responses	96	94	100	88	86	96		
OVSZ LOAD								
oversize load	46	44	44	47	46	44	271	90
? load	1	3	1	2	2	4	13	4
over load	1	1	4	1	1	2	10	3
other responses (4 groups)	2	2	1		1		6	2
Total Correct Responses	46	44	44	47	46	44	271	90
% Correct Responses	92	88	88	94	92	88		
PRK LOT								
parking lot	49	47	49	46	48	48	287	96
park lot	1	3		3	1	1	9	3
did not know			1	1		1	3	1
park cars					1		1	0.3
Total Correct Responses	50	50	49	49	49	49	296	99
% Correct Responses	100	100	98	98	98	98		

B-1 (continued).

PREP TO STOP	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
prepare to stop	48	49	46	50	46	48	287	96
be prepared to stop	1		1		1	1	4	1
preparation to stop	1						1	0.3
other responses (4 groups)		1	3		3	1	8	3
Total Correct Responses	50	49	47	50	47	49	292	97
% Correct Responses	100	98	94	100	94	98		
RGT LN								
right lane		44				42	86	86
did not know		1				4	5	5
? lane		2					2	2
other responses (6 groups)		3				4	7	7
Total Correct Responses		44				42	86	86
% Correct Responses		88				84		
RD WK								
road work	37	44	40	37	43	39	240	80
road workers	1						1	0.3
road working						1	1	0.3
road walk	8	1	2	7	3	6	27	9
road ?	2	1	3	3		2	11	4
road week	1	1	1	2			5	2
did not know		2	2		2	1	7	2
other responses (7 groups)	1	1	2	1	2	1	8	3
Total Correct Responses	38	44	40	37	43	40	242	81
% Correct Responses	76	88	80	74	86	80		

B-1 (continued).

SERV RD	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
service road	49	48	48	45	45	44	279	93
severe road					2	1	3	1
serve road		1		1		1	3	1
other responses (9 groups)	1	1	2	4	3	4	15	5
Total Correct Responses	49	48	48	45	45	44	279	93
% Correct Responses	98	96	96	90	90	88		
TRK STOP								
truck stop	41	43	38	46	45	46	259	86
track stop	3	1	3	1	1		9	3
traffic stop	3	1	5		3	1	13	4
did not know	1	5	3	3	1	3	16	5
other responses (3 groups)	2		1				3	1
Total Correct Responses	41	43	38	46	45	46	259	86
% Correct Responses	82	86	76	92	90	92		
TRAF CLR								
traffic clear	41	38	39	34	38	41	231	77
traffic clearance	3	1	2	3	1	4	14	5
traffic clearing				1	1		2	1
traffic circle	5	8	5	4	4	1	27	9
traffic ?			3	3		2	8	3
traffic closed		1	1	1	2		5	2
traffic closure				2			2	1
other responses (10 groups)	1	2		2	4	2	11	4
Total Correct Responses	44	39	41	38	40	45	247	82
% Correct Responses	88	78	82	76	80	90		

B-1 (continued).

TO DWNTN	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
to downtown	49	46	47	45	45	43	275	92
did not know		2	3	2	2	5	14	5
to town	1				1	1	3	1
to down?		2					2	1
other responses (6 groups)				3	2	1	6	2
Total Correct Responses	49	46	47	45	45	43	275	92
% Correct Responses	98	92	94	90	90	86		
UPR LEVEL								
upper level	23	25	23	22	23	25	141	95
did not know	2			2	1		5	3
up level			1				1	1
unprotected level				1			1	1
Total Correct Responses	23	25	23	22	23	25	141	95
% Correct Responses	92	100	96	88	96	100		
UPPR LVL								
upper level	23	23		22			68	91
did not know	2	1		2			5	7
upper ?		1		1			2	3
Total Correct Responses	23	23		22			68	91
% Correct Responses	92	92		88				
UPPER LVL								
upper level			25		24	23	72	94
did not know					1		1	1
other responses (3 groups)			1		1	2	4	5
Total Correct Responses			25		24	23	72	94
% Correct Responses			96		92	92		

B-1 (continued).

VIC OF	Dallas	Fort Worth	Houston	El Paso	Austin	San Antonio	Total	Total %
vicinity of	9	9	6	3	13	9	49	16
victim of	1	1	1	2	4	1	10	3
vehicle of		3	4	1			8	3
vehicle off	1	1			1	1	4	1
vehicle office	1					2	3	1
did not know	33	33	38	42	27	34	207	69
other responses (12 groups)	5	3	1	2	5	3	19	6
Total Correct Responses	9	9	6	3	13	9	49	16
% Correct Responses	18	18	12	6	26	18		
WET PVMT								
wet pavement	50	42	48	46	49	49	284	95
did not know		3	2	1			6	2
wet payment		2		1	1		4	1
other responses (5 groups)		3		2		1	6	2
Total Correct Responses	50	42	48	46	49	49	284	95
% Correct Responses	100	84	96	92	98	98		
WT LIMIT								
weight limit	44	47	44	43	44	46	268	89
did not know	5	1	3	5	4	4	22	7
with limit		1	1	2			4	1
other responses (4 groups)	1	1	2		2		6	2
Total Correct Responses	44	47	44	43	44	46	268	89
% Correct Responses	88	94	88	86	88	92		

B-2. NB, EB, SB Results.

NB TRAFFIC	Houston	%	US 75 NB	Dallas	%
northbound traffic	15	30	US 75 northbound	26	52
did not know	25	50	United States 75 northbound	8	16
no business traffic	2	4	US 75 ?	8	16
other responses (8 groups)	8	16	US 75 nearby	3	6
			other responses (5 groups)	5	10
EB TRAFFIC	Austin	%	US 180 EB	Fort Worth	%
eastbound traffic	5	10	US 180 eastbound	16	32
did not know	36	72	did not know	15	30
ebbing traffic	3	6	US 180 ?	12	24
emergency traffic	2	4	United States 180	3	6
other responses (4 groups)	4	8	other responses (4 groups)	4	8
SB TRAFFIC	San Antonio	%	US 75 SB	El Paso	%
southbound traffic	5	10	US 75 southbound	9	18
did not know	32	64	did not know	17	34
sub traffic	5	10	US 75 ?	10	20
other responses (8 groups)	8	16	US 75 south	3	6
			US 75 Subway	2	4
			other responses (9 groups)	9	18