



EVALUATION OF ALTERNATIVE TRAFFIC SIGNS FOR USE IN TEXAS BORDER AREAS

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16. Abstract A three-year research project evaluated driver understanding of traffic control devices in Texas border areas. The report describes the activities and findings of the third and final year of the research study. In the third year, two surveys were conducted in both border and non-border locations. The passenger car driver survey addressed the Stop for School Bus, Fasten Safety Belts, and Right Lane Ends signs, plus the sign shape/color code. Spanish-language alternative legends were developed for each standard sign. A total of 1,344 passenger car drivers took part in the survey. The truck driver survey addressed the Weigh Station, Weight Limit, Load Zoned Bridge, and Hazardous Cargo signs, plus the sign shape/color code. Spanish-language alternative legends were developed for each of the word message signs. A total of 525 truck drivers took part in the survey. The results indicated that, in general, the overall comprehension levels for the selected word message signs were improved in the Texas border area through the use of Spanish-legend signs. The research recommends specific Spanish-legend signs that can be used to supplement the Fasten Safety Belts, Right Lane Ends, Weigh Station, Weight Limit, and Load Zoned Bridge signs.					
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Project Advisory Panel

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- Mr. Carlos Chavez, El Paso District, Texas Department of Transportation;
- Mr. Stephen Kern, Office of International Relations, Texas Department of Transportation;
- Mr. Jesus Leal, Pharr District, Texas Department of Transportation;
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CHAPTER 1

INTRODUCTION

Most citizens of the United States who drive on U.S. highways are familiar with the U.S. system of traffic signs, signals, and pavement markings, collectively known as traffic control devices. The meaning of these standard devices, however, may not be as obvious to a motorist visiting from another country. Without the ability to understand the basic traffic control devices that exist in a foreign country, a driver's ease of mobility and safety may be limited.

The Texas-Mexico border area possesses many unique characteristics that make it different from other areas of Texas and which may impact the ability of drivers to understand and properly respond to traffic control devices. The Hispanic influence and the predominance of Spanish as the spoken language are the most significant factors. Not only is there a predominant Hispanic presence among Texas border-area residents, but the number of tourists and truck drivers who speak only Spanish is steadily increasing due to the expected increases in international traffic from the free-trade zone and the North American Free Trade Agreement (NAFTA).

As a result of these and other factors, there is concern that traffic control devices used on highways and streets in the Texas border areas may not adequately meet the information needs of border-area drivers. In particular, there is a concern that signs, many of which were originally designed for English-speaking drivers, may not be well-suited to border drivers, many of whom speak only Spanish, or very limited English. Some of the major factors that might affect the effectiveness of traffic control devices in border areas are:

- the use of two languages (English and Spanish),
- the presence of two systems of measurement (metric and English),
- actual differences in the design of the traffic control devices used in Texas and Mexico, and
- cultural differences between Mexican and U.S. drivers.

Although the Texas Department of Transportation (TxDOT) has been concerned about the effectiveness of traffic control devices in the border area for many years, the issue has remained largely undocumented. Therefore, TxDOT sponsored a three-year research project to investigate the effectiveness of border-area traffic control devices and to develop appropriate recommendations for improving the effectiveness of these devices. This report describes the activities undertaken in the final year of the research project and includes the final recommendations for improving the design and use of traffic control devices in the border areas of Texas. These recommendations will lead to more effective methods of meeting the unique information needs of border-area drivers, thereby reducing driver uncertainty and improving the overall safety of the Texas highway system. Improving the ability of Spanish-speaking drivers to respond to traffic control devices will lead to a friendlier transportation system and encourage the economic development of commercial and tourist facilities in border areas. Improved traffic control devices would also improve TxDOT's ability to restrict overweight and overheight commercial vehicles to highway facilities and service locations that can safely accommodate them.

PREVIOUS RESEARCH ACTIVITIES

This research project focused upon the ability of drivers in the Texas-Mexico border areas to understand traffic control devices. Border driver understanding of traffic control devices was evaluated through the use of several driver comprehension surveys. In each of the three years, the researchers concentrated the survey efforts on specific aspects of the overall issue of border driver understanding of traffic control devices. The first year was primarily a problem identification effort. The primary first-year activities included the identification of pertinent background information and the development and administration of the initial survey. The initial survey addressed existing traffic control devices only, and was administered at border crossings to passenger car drivers with Mexican license plates and truck drivers entering Texas. The second-year effort focused on two groups: automobile drivers with Texas license plates and truck drivers entering Texas. The survey given to Texas drivers was identical to that given to Mexican drivers in the first year, except that a few alternative devices were added to those surveyed in the first year. The truck driver survey included numerous alternative sign designs. A detailed description of the first- and second-year activities and results can be found in the first-year (1) and second-year (2) research reports.

THIRD-YEAR RESEARCH ACTIVITIES

The primary focus of the third year of the research project was the development and evaluation of alternative signs, and the development of recommendations based on the results of the evaluations. The third-year data collection activities consisted of comprehension surveys similar in format to previous surveys. There were two basic survey instruments—one targeted toward drivers of passenger vehicles and another targeted toward heavy vehicle operators. Each survey instrument was administered at border locations and non-border locations. Table 1 summarizes the key aspects of the third-year survey activities. Some of the alternative sign designs developed in the third year included English-language signs, as well as the Spanish-language signs. In order to assess comprehension of the English-language signs among the general Texas driving population, surveys were conducted at non-border locations. This represented the first time that non-border locations were surveyed as part of this research project. The activities and findings from the third year of the research project are described in the following chapters of this report.

Table 1. Survey Activities

Location	Vehicles	Sample Size	Survey Locations	Devices Evaluated	
				Existing	Alternative
Border	Cars	1,116	Laredo, McAllen	5	9 (3 sets of 3 signs)
	Trucks	315	Laredo, Pharr	5	12 (3 sets of 4 signs)
Non-Border	Cars	228	Houston, Bryan	4	1
	Trucks	210	Interstate near Kyle	4	4

The researchers used the results of all three years of survey activities to develop a series of recommendations regarding the design and use of traffic control devices in Texas border areas. Those recommendations are presented in a separate report (3).

CHAPTER 2

DATA COLLECTION ACTIVITIES

All of the third-year data collection activities were associated with the administration and evaluation of surveys that measured driver understanding of selected traffic control devices. The third-year survey activities consisted of two efforts: car and truck surveys administered at various border crossings, and car and truck surveys administered at non-border locations. While there were some similarities in the two types of surveys, there were some important differences. Table 2 identifies the key similarities and differences between the two surveys.

Table 2. Comparison of Third-Year Surveys

Survey	Item	Border	Non-Border
Similarities	Format	Flash card	
	Data Format	Tape Recording	
	Data Analysis	Comprehension Categories (correct, partially correct, etc.)	
	Devices	Existing and Alternatives	
Differences	Sites	Border Crossings	Driver License Stations Weigh Stations
	Primary Language	Spanish	English

In general, both types of surveys were administered in the same manner used in previous years of the research project. An image of a traffic control device was shown to a driver. The driver was asked the meaning or appropriate response to the device. The question and response were recorded on a microcassette tape. After completion of the survey administration, the tapes were reviewed and the responses to individual questions were entered into a spreadsheet for analysis. As part of the analysis, the responses were categorized into one of the categories listed below. Criteria for classifying responses as correct or partially correct were established prior to analyzing the data.

- **Correct** - The response provided by the driver met all of the established criteria for the device.
- **Partially correct** - The response provided by the driver met one or more, but not all, of the established criteria for the device.
- **Incorrect** - The response provided by the driver did not meet any of the established criteria for the device.
- **Not sure** - The driver indicated he/she did not know the meaning/response associated with the device.
- **Indeterminate** - The recorded response was not understandable.

BORDER SURVEYS

The border study was divided into two sets of comprehension surveys: a passenger car driver assessment and a commercial truck driver assessment. The passenger car driver assessment included standard and alternative versions of three highway signs, and the truck driver assessment included standard and alternative versions of three other highway signs whose messages are of specific interest to truck drivers.

Passenger Car Driver Survey

As with the first and second years of the research project, the largest survey samples were composed of drivers of passenger cars. The third-year survey of border-area passenger car drivers focused upon understanding of alternative sign designs. All of the signs evaluated in the effort were word message signs. The alternative designs included both Spanish and English versions of the current standard sign. The intent was to determine if driver understanding could be improved through the use of the alternative designs.

Selection of Devices for Evaluation

The devices to be included in the third-year border-area passenger car survey were selected from those that were evaluated in the first- and second-year surveys. The devices selected for evaluation were based on recommendations from the researchers (2) and input from the Project Advisors. The selection reflects signs which previous research had demonstrated the potential for improvement through changes in the sign design. The three signs selected for evaluation are shown in Figure 1. In addition to the three signs, the researchers included selected sign shapes/colors in the survey.

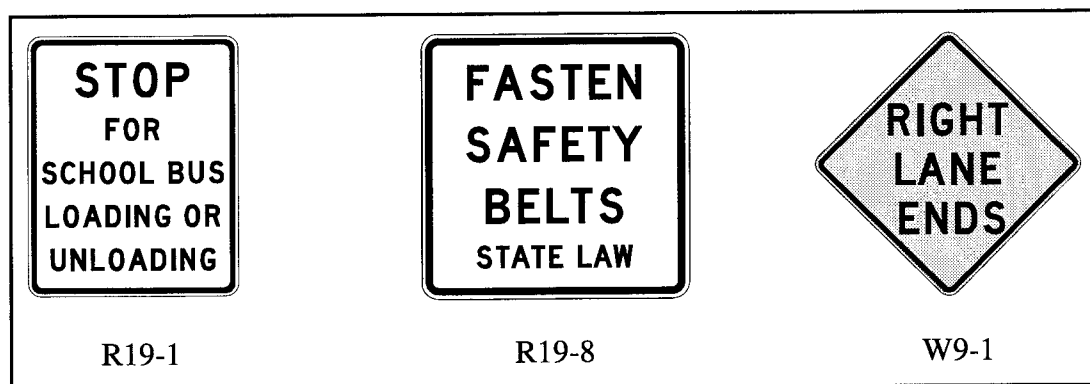


Figure 1. Standard Signs Selected for Evaluation in the Passenger Car Surveys

Development of Alternative Sign Designs

Once the standard signs to be evaluated had been selected, the researchers began the development of alternative designs for the signs. For the school bus sign, the process included development of both English- and Spanish-legend signs. For the other two signs, only Spanish-legend alternatives were developed. A key process in the development of alternative designs was

a critical review of current signing practices for similar signs in Mexico and other states in the U.S.

In the review of Mexican signs, researchers looked for Spanish-legend signs which conveyed the same intent as those U.S. signs which are not well understood by border-area drivers. If similar Spanish-legend signs existed and were perhaps familiar to border-area drivers, these legends may result in higher comprehension levels. However, no Spanish versions of the signs in the survey sample were included in the Mexican version of the MUTCD, the *Manual de Dispositivos para el Control del Transito en Calles y Carreteras* (4). In part, this reflected the predominance of symbol signing used in Mexico. The Mexican manual did have a symbol sign similar to the U.S. sign for Lane Reduction Transition (W4-2). In addition, until recently, there was no national law mandating seat belt usage. Therefore, there was no national standard on seat belt signing. Finally, Mexico did not have the same type of school bussing system for the mass transport of school children. Consequently, as with FASTEN SAFETY BELTS - STATE LAW, no Spanish-legend sign existed which would be equivalent to the STOP FOR SCHOOL BUS LOADING OR UNLOADING.

Without Mexican standards to use as a starting point, the researchers consulted several native Spanish speakers from Mexico and various Central and South American countries as well as several people who have traveled extensively in Spanish-speaking countries. These people were asked how they would translate the signs in the survey sample and were then given various alternatives to critique. Potential legends (both Spanish and English) were evaluated by a TTI team on the following criteria: how well the intended message was conveyed, consistency with current Mexican practice, and brevity of the message. It should be noted that the exact literal translation from English to Spanish was often not a viable alternative due to an unreasonable legend length or potential ambiguity. The “best” alternatives were then selected for inclusion in the field survey efforts. Up to three Spanish legends were developed for each sign in the survey set.

For the STOP FOR SCHOOL BUS LOADING OR UNLOADING sign, which had a low comprehension rate among English-speaking drivers, also determined from previous TTI research (2), an alternative English-legend was also developed. The sign STOP FOR SCHOOL BUS WHEN RED LIGHTS FLASHING was a combination of the Pennsylvania and Minnesota signs for this application. These signs are illustrated in Figure 2.

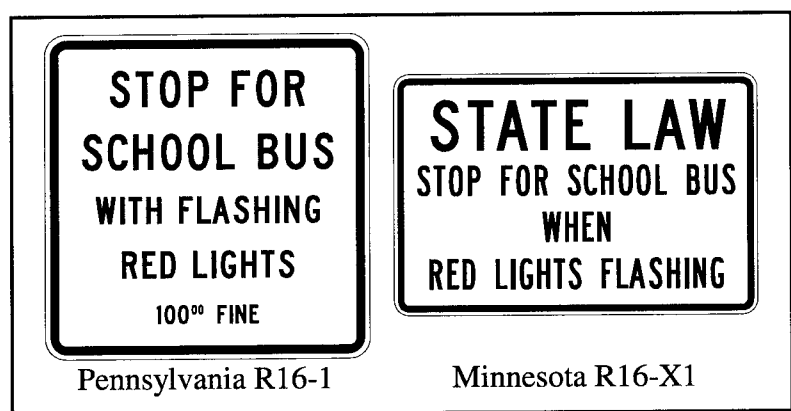


Figure 2. Stop for School Bus Signs from Other States

Upon completion of the alternative development, the standard signs and alternatives were presented to the Project Advisors for review. Figure 3 illustrates the standard and alternative sign designs that were selected for evaluation in the border-area passenger car survey.

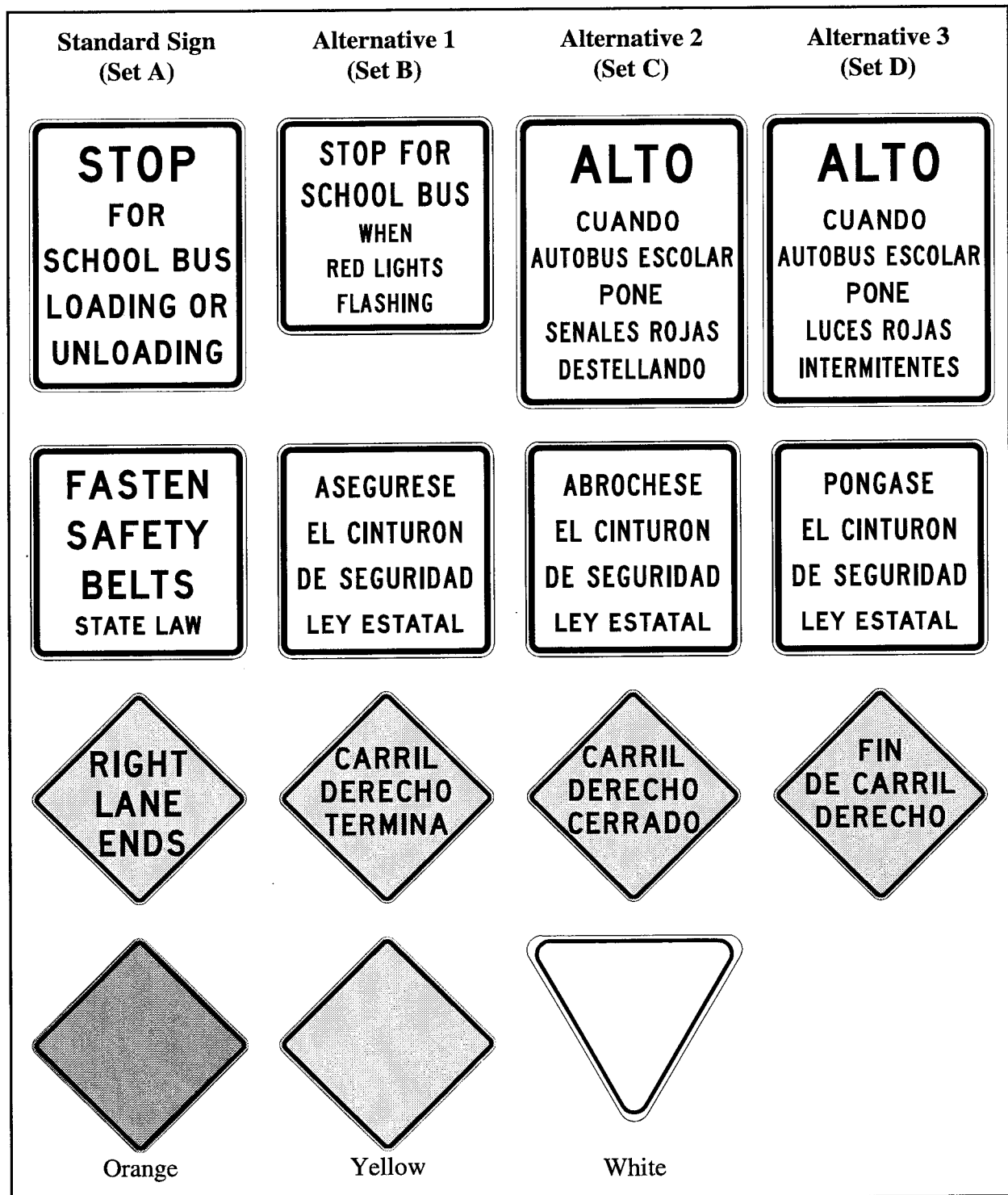


Figure 3. Signs Selected for Evaluation in the Border Passenger Car Survey

Survey Instrument Format

The survey format consisted of flash cards with the sign graphics displayed as in-context pictures. A close-up of each sign was also included. This represented a departure from previous years' surveys, as only the close-up image of a sign was presented in the first- and second-year surveys. Though in practice the alternative Spanish legends would be paired with the standard English signs, each sign was shown to the survey participants as a stand-alone sign. Figure 4 illustrates a typical example of a flash card. The front of the flash card contains the sign image that was presented to the driver. The back of the flash card contained the primary and follow-up questions that the surveyor asked the driver. These questions were written in both Spanish and English. The order of the flash cards in each survey set was randomized so as to eliminate bias due to sign order. Participants were asked questions regarding their interpretation of each sign legend. Based on the response received, surveyors asked one or more follow-up questions to make certain the participant truly understood and did not simply read back the legend. However, if the participant gave a complete response to the primary question, the follow-up questions were not asked.

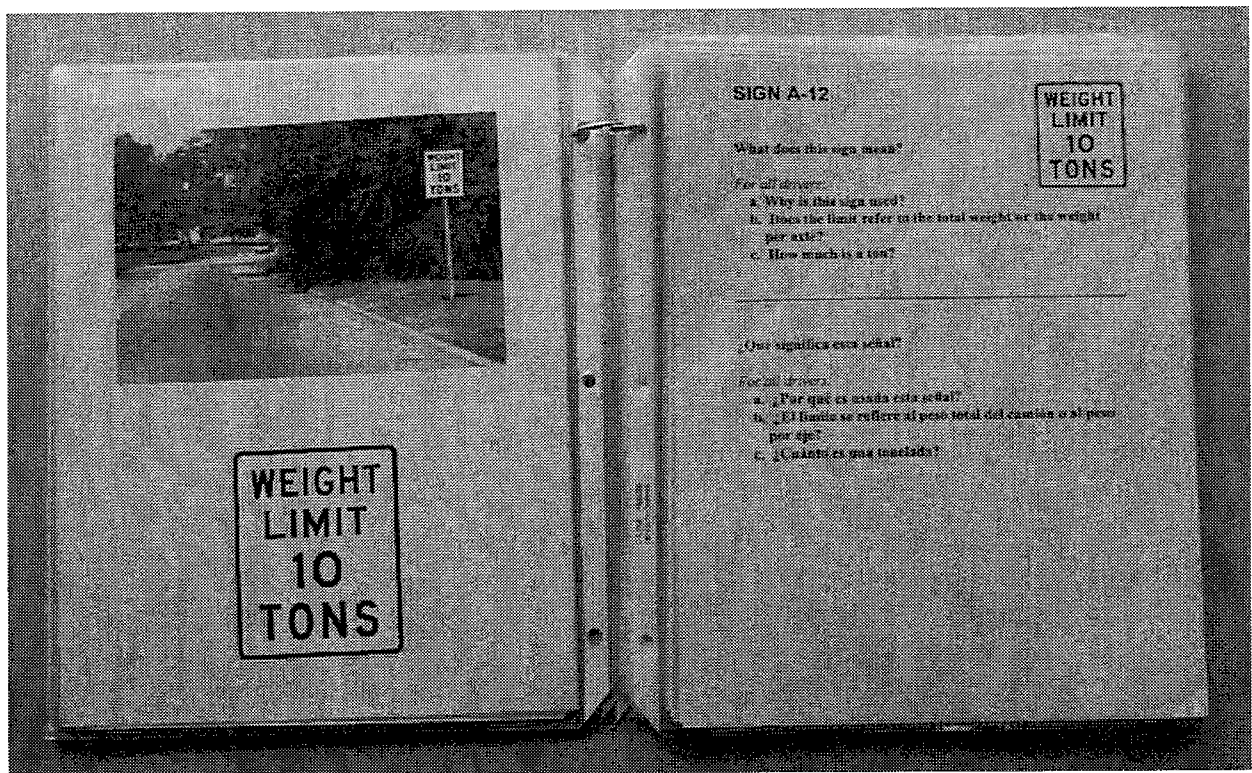


Figure 4. Typical Flash Card

To complete a preliminary evaluation of the survey instrument, a pilot survey was conducted in a Driver License Station in Bryan. Specifically, the researchers worked to refine the wording of the primary survey questions and follow-up questions such that these questions would elicit the most complete responses from survey participants. A trial-and-error method was used, discarding questions which did not elicit complete responses from participants. Based on the results of the pilot survey, the wording of some questions was slightly modified.

Survey Administration

The target sample size was 600 to 800 surveys. Bilingual (Spanish and English) and English-speaking researchers administered 1,116 surveys over three weekends at international bridge crossings in Laredo (825 surveys) and McAllen (291 surveys). In Laredo, surveys were conducted at International Bridge #1. In McAllen, surveys were conducted at the Hidalgo Bridge and at the Pharr Bridge. Two different survey procedures were employed. At International Bridge #1 in Laredo and the Pharr Bridge in McAllen, surveyors targeted drivers who were waiting in the traffic queue to proceed through U.S. Customs Service inspection stations (drivers entering the U.S.). Upon approaching a vehicle, the surveyor introduced himself/herself and the survey, and asked if the driver would consent to participate. Participating drivers were asked what was the primary language spoken in their home. The survey was then completed in their primary language. Bilingual speakers were given the option of completing the survey in Spanish or English. To keep traffic moving, surveyors walked alongside the vehicle as it advanced in the queue.

At the Hidalgo Bridge in McAllen, Customs officials requested that the surveyors position themselves downstream from the Customs booths near a pedestrian crossing next to the inspection canopy. In this setup, researchers approached the drivers after they had cleared the inspection station as they slowed for a speed bump in advance of the pedestrian crossing. If a driver consented to participate, surveyors directed him or her to one of several empty inspection bays. Again, participating drivers were asked what was the primary language spoken in their home. The survey was then completed in their primary language. Bilingual speakers were given the option of completing the survey in Spanish or English.

In all cases, responses were accepted only from the driver of the vehicle. Collaborative efforts involving passengers were not allowed. The survey required approximately three to four minutes to complete. All responses were audio-recorded for future playback and reduction. Participants included both U.S. and Mexican drivers as identified by the vehicle license plates. No data were collected from drivers queued to enter Mexico as this would require the cooperation of the Mexican government and customs officials.

Finally, each driver only saw one of the four survey sets, and no driver was shown more than one alternative for each sign. In addition to the survey questions, each survey administrator audio-recorded certain demographic information about both the driver and the vehicle. The following information was recorded by the surveyor for all drivers surveyed:

- gender;
- approximate age;
- whether the participant drives more frequently in Texas or in Mexico;
- the final destination (city) of the driver; and
- the vehicle license plate (Texas or Mexico).

Truck Driver Survey

The results of the first- and second-year surveys indicated that some of the signs with lower comprehension levels were truck-related signs evaluated in the truck driver surveys. The third-year border-area survey of truck drivers focused upon the understanding of three word message signs and one symbol sign, plus alternative designs for each sign. Alternatives included either English- or Spanish-language legends for the word message signs and alternative symbols for the symbol sign.

Identification and Selection of Traffic Control Devices

As with the signs included in the passenger car assessment, the signs included in the truck driver evaluation were selected based on recommendations of the researchers (2) and input from the Project Advisors. The selection of truck-related signs was based on the findings of previous research and engineering judgement. The researchers selected only those signs with a potential for improving comprehension through changes in sign design. The four signs selected for evaluation in the border areas are shown in Figure 5.

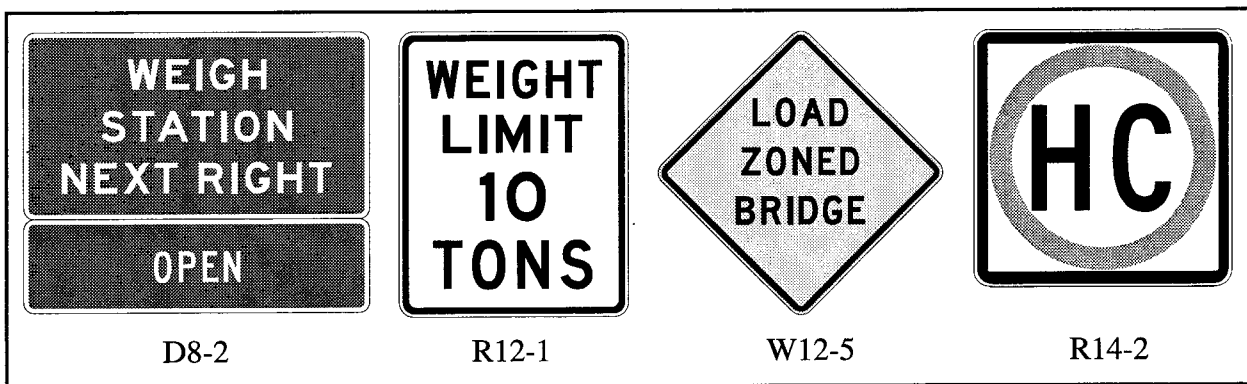


Figure 5. Standard Signs Selected for Evaluation in the Truck Surveys

Development of Alternative Devices

To develop the best possible alternative legends for those signs identified, standard signing practice in Mexico was reviewed. Specifically, the researchers looked for Spanish-legend signs which conveyed the same intent as those U.S. signs which are not well understood by border-area drivers. If similar Spanish-legend signs existed that might be familiar to border-area drivers, these legends may have demonstrated higher comprehension levels. However, as with the passenger car driver sample, no Spanish versions of the signs in the survey sample are included in the *Manual de Dispositivos para el Control del Transito en Calles y Carreteras* (4).

Without Mexican standards to use as a starting point, the researchers again consulted several native Spanish speakers from Mexico and various Central and South American countries as well as several people who had done extensive travel in Spanish-speaking countries. These people were asked how they would translate the signs in the survey sample and were then given various alternatives to critique. Potential legends (both Spanish and English) were evaluated by the researchers on the following criteria: how well the intended message was conveyed, consistency

with current Mexican practice, and brevity of the message. It should be noted that the exact literal translation from English to Spanish was often not a viable alternative due to an unreasonable legend length or potential ambiguity. The “best” alternatives were then selected for inclusion in the field survey efforts. Up to three Spanish legends were developed for each sign in the survey set.

For the LOAD ZONED BRIDGE sign, which had a low comprehension rate among English-speaking drivers, as determined in previous TTI research (2), an alternative English-legend was also developed—Bridge Limit. This legend reflected comments from the Project Advisors and the potential to use this sign for various bridge restrictions—weight, width, or height.

Several alternatives were considered for the standard Hazardous Cargo (HC) routing signs. In the first- and second-year surveys, various versions of these signs were found to have a low level of comprehension among truck drivers in the border area (2). A proposed alternative displaying the National Fire Protection Agency (NFPA) “diamond” raised the level of comprehension in the second-year surveys; however, further testing was needed both in border and non-border areas. Figure 6 explains the NFPA symbol. Another alternative used the abbreviation HM for hazardous material or hazmat. The final survey sets were evaluated and approved by the Project Advisors. Figure 7 shows the standard U.S. signs that were evaluated and their alternatives.

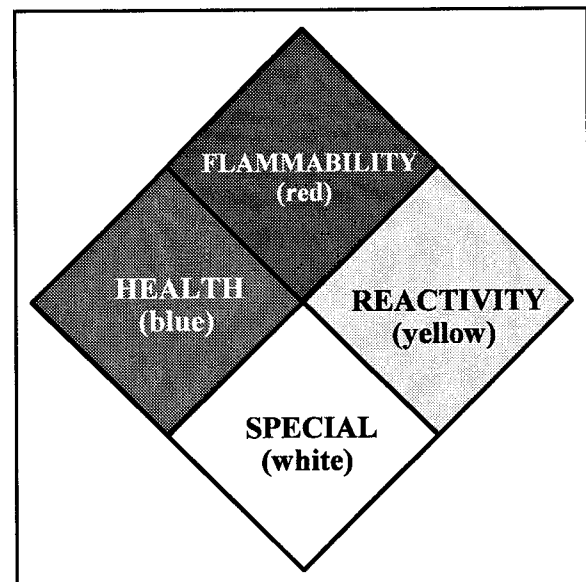


Figure 6. NFPA Chemical Hazard Label

Survey Instrument Format

Similar to the survey of passenger car drivers, the survey format for the truck driver survey consisted of flash cards with the sign graphics displayed in-context pictures. A close-up of each sign was also included. Though in practice the alternative Spanish legends would be paired with the standard English signs, each sign was shown to the survey participants as a stand-alone sign. The order of the flash cards in each survey set was randomized so as to eliminate bias due to sign order. Participants were asked questions regarding their interpretation of each sign legend. Again, follow-up questions were used to determine whether the participant had a true understanding of the intended message or was simply reading the legend.

To complete a preliminary evaluation of the truck survey instrument, a pilot survey was conducted in a Driver License Station in Bryan in conjunction with the pilot passenger car survey. Specifically, the researchers worked to refine the wording of the primary survey questions and follow-up questions such that these questions would elicit the most complete responses from survey participants. A trial-and-error method was used, discarding questions to which participants did not respond well. Based on the results of the pilot survey, the wording of some questions was slightly modified.

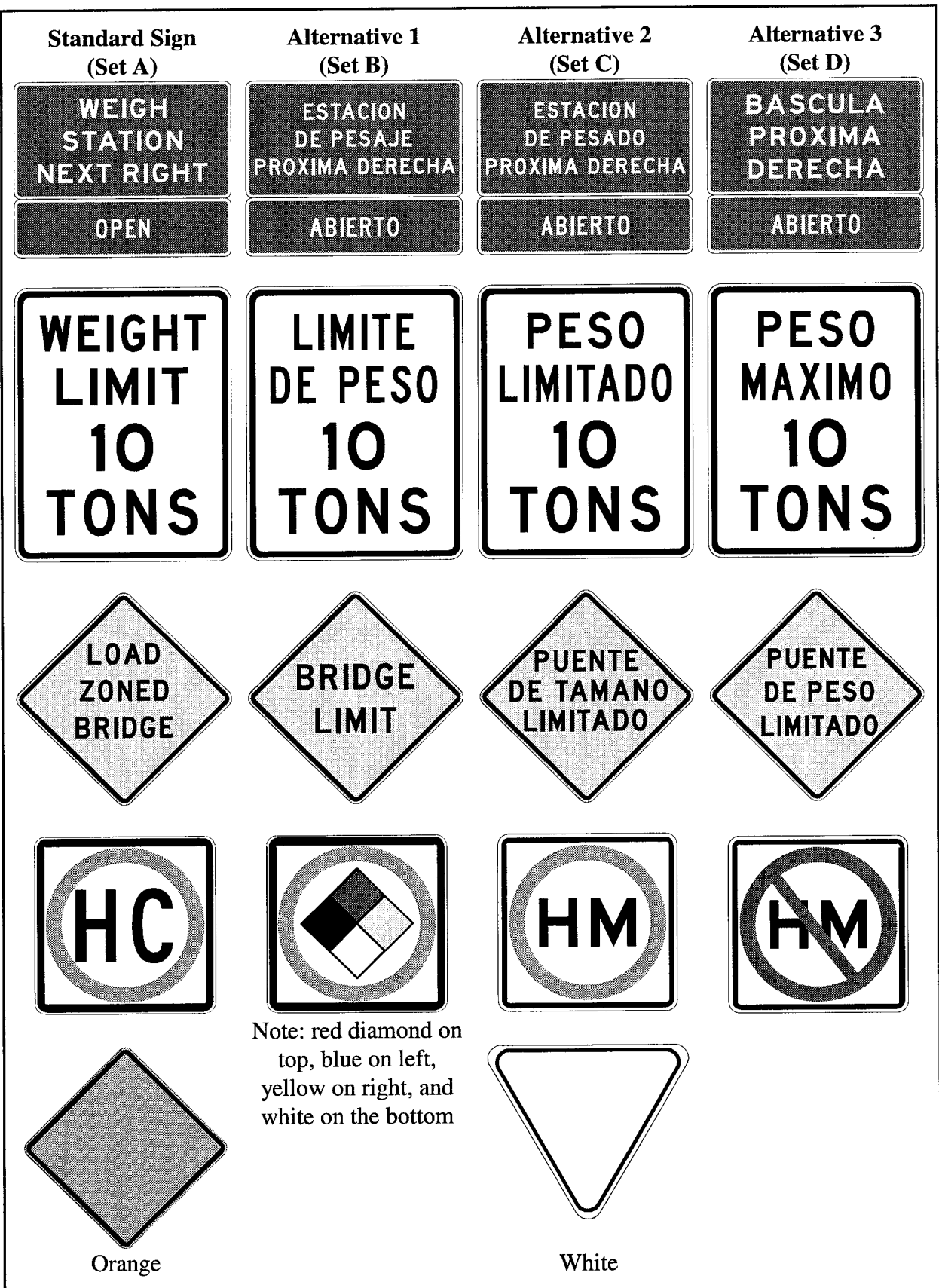


Figure 7. Signs Selected for Evaluation in the Border Truck Survey

Survey Administration

The target sample size for the truck driver evaluation was 200 to 300 surveys. Bilingual (Spanish and English) researchers administered 315 surveys over two weekends at the Columbia-Solidarity international bridge crossing in Laredo (294 surveys) and at the Pharr Bridge in McAllen (21 surveys). The surveys were administered to truck drivers entering the U.S. at the Columbia-Solidarity Bridge. Surveyors targeted drivers who were waiting while their trucks were being inspected by U.S. Customs Service officials. To ensure the safety of the surveyors, a U.S. Customs agent would first approach the vehicle and ask the driver to turn off his/her vehicle and step down from the truck. The agent explained briefly what the survey entailed and asked if the driver would consent to participate. Consenting drivers were then directed toward an available surveyor. Upon approaching a truck driver, the surveyor introduced himself/herself and explained the objectives of the survey. Participating drivers were asked what was the primary language spoken in their home. The survey was then completed in the truck driver's primary language. Bilingual speakers were given the option of completing the survey in Spanish or English.

A limited number of surveys were collected at the Pharr Bridge. The weekend on which survey activities were conducted in McAllen, Mexican Customs officials were installing a new computer system to process truck traffic. Consequently, no trucks were permitted to cross the border from Mexico. The few surveys that were collected were from drivers who had crossed previously and were waiting at the U.S. Customs facility to have their loads inspected. The same survey protocol was followed.

As in the passenger car surveys, responses were accepted only from the driver of the truck, and collaborative efforts involving passengers were not allowed. The survey took approximately two to three minutes to complete. All responses were audio-recorded for future playback and reduction. Participants included both U.S. and Mexican truck drivers at the international bridge crossings. Truck drivers were classified as Mexican or American by the vehicle license plate.

In all cases, each driver only saw one of the four survey sets, and no driver was shown more than one alternative for each sign. In addition to the survey questions, each survey administrator audio-recorded certain demographic information about both the driver and the vehicle. The following information was recorded for all drivers surveyed:

- gender;
- approximate age;
- whether the participant drives more frequently in Texas or in Mexico;
- the final destination (city) of the driver; and
- the vehicle license plate (Texas or Mexico).

NON-BORDER SURVEYS

The first two years of the research project identified several traffic signs that were frequently misunderstood by drivers in the Texas/Mexico border area. As the research continued, alternatives for these signs were developed and tested in the border region. Though the

comprehension difficulty could likely be attributed to Spanish-speaking drivers trying to read English-legend signs, there existed the possibility that the signs were unclear to all drivers, both in border and non-border areas. Prior to this point in the research, however, no effort had been made regarding non-border driver comprehension of the signs that are frequently misinterpreted in the border area. In order to assess the impact of the potential alternative designs on non-border drivers, additional data from non-border areas were collected to determine if these signs are misinterpreted by all drivers or exclusively by border-area drivers. Two non-border surveys were administered—one to passenger car drivers and a second to truck drivers.

Cars

To get an assessment of non-border passenger car driver understanding of the selected signs, the researchers administered surveys at Driver License Stations in Houston and Bryan. This type of location has been used in previous TTI research and found to be very appropriate for the desired driver population. Only the English-language standard and alternative signs were included in this survey. There were a total of four signs in the survey, plus three shape questions.

Identification and Selection of Traffic Control Devices

The non-border surveys evaluated the same standard traffic signs as the border surveys, plus the English-language alternative for the school bus sign. The signs in the non-border passenger car survey are illustrated in Figure 8.

Survey Instrument Format

Again, the non-border surveys used the same format as the border surveys, a series of flash cards with in-context pictures and a close-up of the traffic sign. Each participant was asked one or more questions regarding their interpretation of the sign legend. The survey itself was divided into two different sets; each set contained three traffic signs. To assure a similar number of responses for each set, the survey administrators would alternate between Set A and Set B; each participant saw only Set A or Set B, not both.

Survey Administration

The non-border passenger car surveys were administered to waiting patrons and others at two Department of Public Safety (DPS) Driver License Stations within Texas. A total of 117 drivers in Houston and 109 drivers in Bryan participated in the survey. Researchers would approach patrons waiting to be serviced by DPS personnel or individuals who were waiting on a patron (these individuals typically provided transportation for the patron). Researchers would introduce themselves, explain the survey, and ask if a patron would consent to participate. Once a patron gave verbal permission, the researcher began the survey. The entire survey was usually administered in less than one minute.

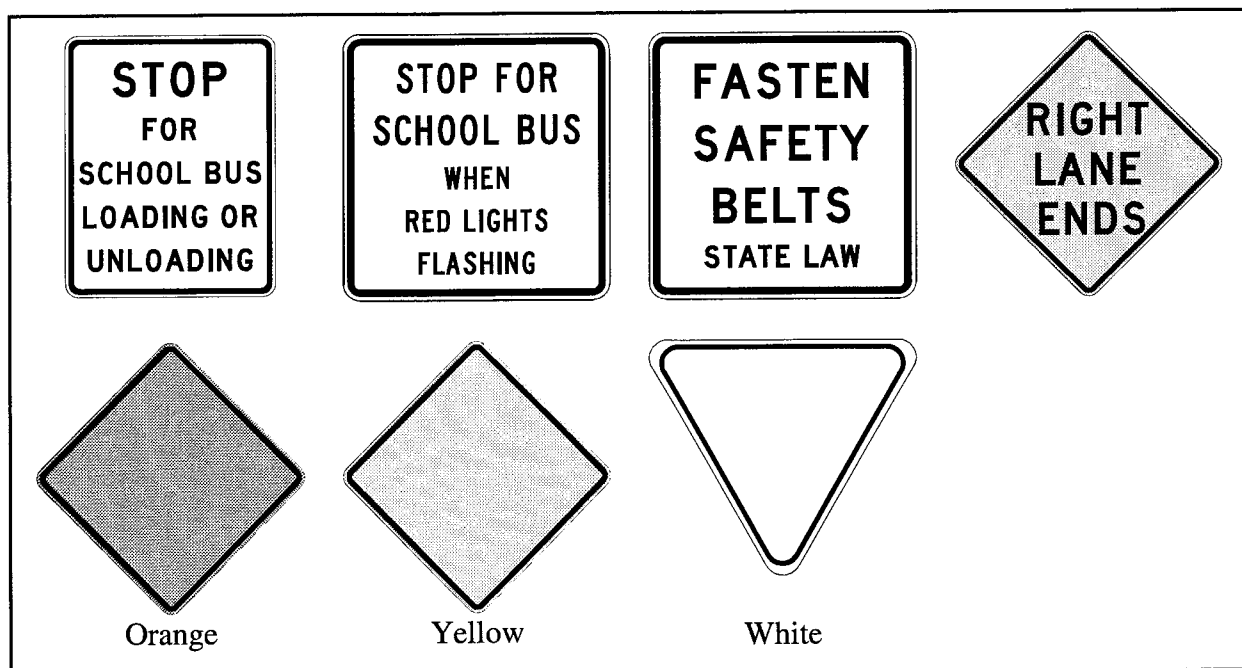


Figure 8. Signs Selected for Evaluation in Non-Border Passenger Car Survey

Trucks

The English-language versions of the truck signs were evaluated in a non-border survey of truck drivers. The survey was administered at a truck weigh station. There was a total of three signs in the truck driver survey, plus two sign shapes.

Identification and Selection of Traffic Control Devices

The truck driver survey evaluated three standard traffic signs. All three signs were the same as the standard sign included in the border surveys. The Weigh Station sign was not included as the surveys were conducted at a weigh station. An alternative for LOAD ZONED BRIDGE, BRIDGE LIMIT was also included. Figure 9 illustrates the signs included in the non-border truck drivers' survey. Several alternatives to the standard Hazardous Cargo signing were also evaluated: an "HM" symbol, similar to the current "HC" and the National Fire Protection Agency four-color diamond symbol.

Survey Instrument Format

The truck survey instrument was administered in a flash card format. There were four sets each containing four traffic signs. One side of the flash card contained a picture of a road scenario with a traffic sign and an enlarged picture of the traffic sign. As with the passenger car survey, each participant saw only one set of signs, and all responses were audio-recorded for data reduction purposes.

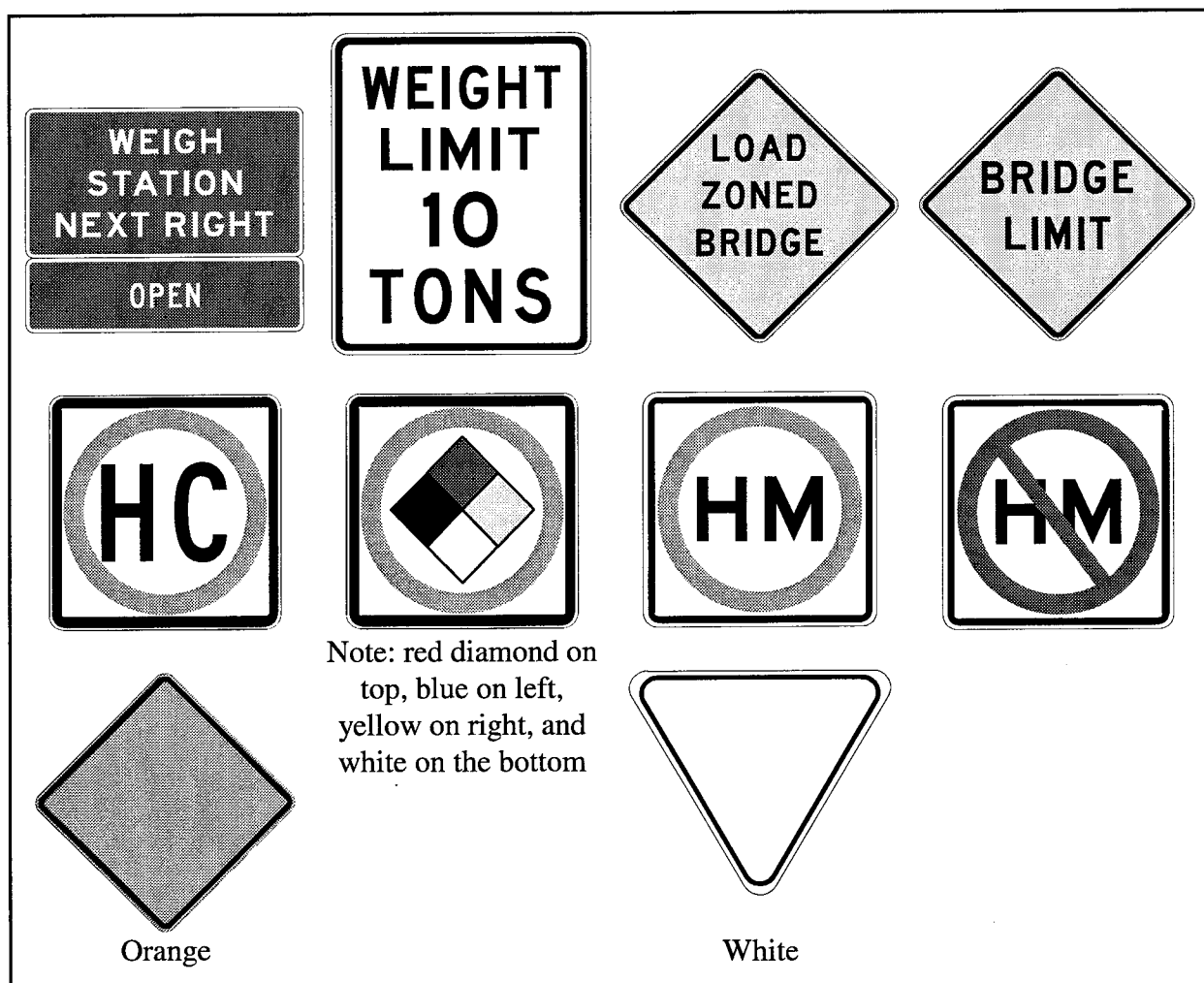


Figure 9. Signs Selected for Evaluation in the Non-Border Truck Survey

Survey Administration

The non-border truck driver survey was administered at a weigh station along Interstate Highway 35 in Kyle during July of 1998. This weigh station was selected because it operates frequently and has a high truck volume. In cooperation with the Department of Public Safety the weigh station was opened for the purpose of administering the survey. The surveys were administered to a total of 210 truck drivers over a four-hour period.

By law, trucks were required to exit into an “open” weigh station, which, in this case, was a three-lane station along the side of the interstate. DPS officers would screen the trucks and direct them to one of the three lanes. A researcher was positioned in each of the outside lanes. The trucks would pull forward to the researcher. Once the truck stopped, the researcher approached the driver of the truck, introduced himself, explained the survey, and asked if the driver was willing to participate. Every truck driver who was approached participated in the survey. When truck traffic would begin to queue, the DPS officers would direct trucks through the middle lane to prevent excessive congestion. The survey was typically completed in less than one minute, and the truck driver did not have to exit his/her vehicle.

CHAPTER 3

DATA ANALYSIS AND RESULTS

As mentioned in the previous chapter, the driver survey responses were recorded on tape for later analysis. Following completion of the data collection phase, the tapes were then analyzed by the researchers. This chapter describes the process used to analyze the data and the results of the analysis.

DATA REDUCTION

In reducing the audio data, the researchers sorted each response to the initial and follow-up questions by the concepts considered vital to comprehension of the sign being evaluated. Each response was then categorized as *correct*, *partially correct*, or *incorrect* based on carefully developed criteria for each response category. If a respondent mentioned all of the key concepts, that response was considered *correct*. *Partially correct* responses were those which included some, but not all, of the key concepts. The criteria for *correct*, *partially correct*, and *incorrect* depended upon each individual sign. The remaining responses fell into one of two categories: *not sure* which meant the driver indicated he/she did not know the meaning of the sign, and *indeterminate* which was used to describe those responses in which the tape recording was inaudible.

To determine the percentages for each response category, the numbers of *correct*, *partially correct*, *incorrect*, and *not sure* responses were divided by the sample size for that particular sign. *Indeterminate* responses were not included in the sample size when calculating the response rates. The overall comprehension level for each sign was determined by totaling the number of *correct* plus *partially correct* responses and dividing the sum by the sample size for that sign. The researchers also examined the *incorrect* responses to gain insight into how the drivers who did not understand the intended meanings did interpret the signs.

STATISTICAL ANALYSIS

Once the response rate percentages were determined for each sign included in the survey sample, the researchers compared the comprehension levels for the various signs. For both the passenger car driver and truck driver survey samples, the overall comprehension level (correct plus partially correct rates) for each alternative of a given sign was then compared to the overall comprehension level for the standard U.S. sign. Comparisons were also made between border and non-border comprehension levels.

Statistical comparisons between the comprehension levels were made using the standard normal z-test. The test requires the following two assumptions (5):

- the sample population approximates the actual driving population; and
- the sample population can be characterized by the normal distribution.

Larger sample sizes increase the confidence expressed by the test statistic. Calculation of a confidence interval gives a measure of the accuracy of the results. Using a 90 percent confidence coefficient, a confidence interval for the survey results was calculated with the formula in Equation 1.

$$\text{Confidence Interval} = \hat{\pi} \pm z_{\alpha/2} \sigma_{\hat{\pi}}, \quad (\text{Equation 1})$$

where: $\hat{\pi}$ = Proportion of correct response, expressed as a percentage;
 $z_{\alpha/2}$ = Standard normal deviate at a $(1-\alpha/2)$ confidence interval;
 α = Indication of confidence interval and Type I error; and
 $\sigma_{\hat{\pi}}$ = Sample standard deviation.

The sample standard deviation was calculated using the formula in Equation 2.

$$\sigma_{\hat{\pi}} = \sqrt{\frac{\pi(1-\pi)}{n}}, \quad (\text{Equation 2})$$

where: n = Sample size; and
 π = Correct response rate.

For example, assuming a 50 percent correct response rate in the population ($\pi=0.50$), a sample size of 200 ($n = 200$), and a 90 percent confidence coefficient ($\alpha = 0.10$, $z_{\alpha/2} = 1.645$), the formula in Equation 1 was used to determine the confidence interval.

$$\text{C.I.} = \hat{\pi} \pm z_{\alpha/2} \sigma_{\hat{\pi}} = 50.0 \pm 100 \times 1.645 \sqrt{\frac{0.5(1-0.5)}{(200)}} = 50.0 \pm 5.8 \text{ percent} \quad (\text{Equation 3})$$

$$\text{Confidence Interval} = (44.2, 55.8)$$

To determine if any of the alternatives had a comprehension level which was statistically better than the standard sign, a simple z-test for a population was performed. The first step of this test was to verify that the sample was sufficiently large to make an assumption of normality. The sample size must be large enough that Equations 4 and 5 are valid.

$$n\pi > 5, \quad (\text{Equation 4})$$

$$n(1-\pi) > 5, \quad (\text{Equation 5})$$

The next step was to formulate the null and alternative hypotheses as shown in Equations 6 and 7.

$$H_o: \pi_A = \pi, \quad (\text{Equation 6})$$

$$H_a: \pi_A > \pi, \quad (\text{Equation 7})$$

where: H_o = Null hypothesis;
 H_a = Alternative hypothesis;
 π_A = Proportion of correct response for the alternative legend; and
 π = Proportion of correct response for the standard legend.

The null hypothesis was rejected if:

$$Z \geq Z_{\alpha},$$

meaning that the alternative was statistically better than the standard sign. Equation 8 shows the calculation of the test statistic, z .

$$z = \frac{\pi_A - \pi}{\sigma_{\hat{\pi}}}, \quad \text{(Equation 8)}$$

where: z = Test statistic;
 π_A = Proportion of correct response for the alternative legend;
 π = Proportion of correct response for the standard legend; and
 $\sigma_{\hat{\pi}}$ = Pooled sample standard deviation.

As the two proportions being compared are from samples, the standard deviation must be estimated using the formula shown in Equation 9.

$$\sigma_{\hat{\pi}} = \sqrt{\pi(1-\pi)\left(\frac{1}{n} + \frac{1}{n_A}\right)}, \quad \text{(Equation 9)}$$

where: π = Proportion of correct responses common to both populations;
 n = Sample size for the standard legend; and
 n_A = Sample size for the alternative legend.

The best estimate of π is shown in Equation 10.

$$\hat{\pi} = \frac{\text{Total number of correct responses}}{\text{Total number of responses}} = \frac{y + y_A}{n + n_A}, \quad \text{(Equation 10)}$$

where: $\hat{\pi}$ = Proportion of correct responses common to both samples;
 y = Number of correct responses for the standard legend; and
 y_A = Number of correct responses for the alternative legend.

When multiple pairwise comparisons are made based on the same sample, the overall error rate is higher than the error rate for each individual test. Therefore, one must account for the additional error by making the individual comparisons at a higher significance level. The additional error was accounted for by the researchers using the calculation shown in Equation 11.

$$\text{Overall Significance Level} = (1 - \alpha)^c, \quad \text{(Equation 11)}$$

For example, when three comparisons are made, in order for the overall significance level to be 0.90 (an overall error rate of 0.10) the individual error rate for each test must be 0.0345. Therefore it is the individual error rate, 0.0345, that must be used in selecting a tabular z -value. However, the significance level of the test is based on the overall error rate. In this example, the significance level was 90 percent.

SURVEY RESULTS

The remaining portion of this chapter presents the results of the passenger car driver and truck driver surveys. This includes the demographics and the results for both border and non-border survey locations. A more detailed discussion of the findings of these results is presented in the next chapter.

Demographics

The demographics of the passenger car driver and truck driver surveys are indicated in Tables 3 and 4, respectively.

Results of Passenger Car Driver Surveys

The results of the passenger car driver survey are presented in the following sections. The correct and partially correct response rates are presented for each sign for both the border and non-border survey locations. For the border surveys, the results were further divided into those that speak Spanish as their primary language and those that speak English as their primary language or those that are bilingual. In addition to the response rates, comparisons of the relative sign performance are presented, with indications as to whether a given alternative was statistically better than the standard sign. As indicated previously, an alpha-level of 0.10 was used to establish the confidence interval, and an alpha-level of 0.0345 was used to complete the statistical testing. The purpose of the statistical test was to determine whether the comprehension level for any one of the alternatives showed a statistically significant improvement over the comprehension level for the standard sign. More detailed information about the survey results is presented in Appendix A. This information includes all categories of responses for both the primary and all the follow-up questions. It also indicates the key response concepts indicated by drivers.

In the passenger car driver surveys, researchers evaluated three standard traffic signs and three alternatives for each sign, for a total of 12 signs. The surveys were administered to 1,116 border-area drivers in Laredo and McAllen and 228 non-border drivers in Bryan and Houston. The survey instruments in the non-border locations did not include the Spanish-legend signs. In all surveys, each driver saw only one of the survey sets, and no driver was shown more than one version of any given sign.

Stop for School Bus Sign

Four versions of the **Stop for School Bus Loading or Unloading** sign were presented to drivers (R19-1). In addition to the standard sign, one English- and two Spanish-legend signs were evaluated. Table 5 presents the survey questions and response concepts for the school bus signs evaluated in the survey. These are the questions that were asked of drivers (in either Spanish or English) and the concepts that were used to classify the responses as *correct*, *partially correct*, *incorrect*, or *not sure*.

Table 3. Demographic Characteristics of Passenger Car Driver Survey Participants

Demographic Group		BORDER		NON-BORDER	
		Number	Percentage	Number	Percentage
Total Number of Surveys ¹		1,116	100.0%	228	100.0%
Gender	Male	829	74.6%	119	52.2%
	Female	287	25.7%	109	47.8%
Age	Young (16 to 24)	231	20.7%	50	22.0%
	Adult (25 to 55)	768	68.8%	167	73.2%
	Senior (55 and over)	117	10.5%	11	4.8%
Primary Language Spoken at Home	English	179	16.0%	104	45.7%
	Spanish	904	81.0%	8	3.5%
	Both	33	3.0%	0	0.0%
	Other	0	0.0%	7	3.0%
	Unknown	0	0.0%	109	47.8%
Where They Do Most of Their Driving	Texas	451	40.4%	N/A	N/A
	Mexico	413	37.0%	N/A	N/A
	Both	189	16.9%	N/A	N/A
	Other	35	3.1%	N/A	N/A
	Unknown	28	2.5%	N/A	N/A
License Plate	Texas	511	45.8%	N/A	N/A
	Mexico	532	47.7%	N/A	N/A
	Other	54	4.8%	N/A	N/A
	Unknown	19	1.7%	N/A	N/A
Survey City	Laredo	825	73.9%	N/A	N/A
	McAllen	291	26.1%	N/A	N/A
	Houston	N/A	N/A	119	47.8%
	Bryan	N/A	N/A	109	52.2%

Notes: ¹Includes the indeterminate responses.
N/A - Not applicable.

Table 4. Demographic Characteristics of Truck Driver Survey Participants

Demographic Group		BORDER		NON-BORDER	
		Number	Percentage	Number	Percentage
Total Number of Surveys ¹		315	100.0%	210	100.0%
Gender	Male	314	99.7%	202	96.2%
	Female	1	0.3%	8	3.8%
Age	Young (16 to 24)	4	1.3%	7	3.3%
	Adult (25 to 55)	311	98.7%	187	89.0%
	Senior (55 and over)	0	0.0%	16	7.7%
Primary Language Spoken at Home	English	8	2.5%	173	82.4%
	Spanish	307	97.5%	23	11.0%
	Both	0	0.0%	13	6.2%
	Other	0	0.0%	1	0.4%
	Unknown	0	0.0%	0	0.0%
Where They Do Most of Their Driving	Texas	24	7.6%	N/A	N/A
	Mexico	129	41.0%	N/A	N/A
	Both	82	26.0%	N/A	N/A
	Other	0	0.0%	N/A	N/A
	Unknown	80	25.4%	N/A	N/A
License Plate	Texas	28	8.9%	N/A	N/A
	Mexico	265	84.1%	N/A	N/A
	Other	1	0.3%	N/A	N/A
	Unknown	21	6.7%	N/A	N/A
Survey City	Laredo	294	93.3%	N/A	N/A
	McAllen	21	6.7%	N/A	N/A
	Kyle	N/A	N/A	210	100.0%

Notes: ¹Includes the indeterminate responses.
N/A - Not applicable.

Table 5. Questions and Response Concepts for School Bus Signs

Primary and Follow-Up Questions		Correct Response Concept	Partially Correct Response Concept
Stop for School Bus Loading or Unloading (R19-1)		   	
What does this sign mean?		Stop for school bus loading and unloading or if red lights are flashing	Verbatim ¹ or school bus
Follow-up	When do you have to stop for a school bus?	When the bus is loading or unloading or when the red lights are flashing	None
	Why do you have to stop for a school bus?	Children crossing the street, safety, red lights flashing, or loading and unloading	None
	Does traffic in both directions have to stop?	Yes	None

Note: ¹A verbatim response is one in which the survey respondent simply read the sign legend out loud without providing any additional explanation.

The results of the third-year surveys for these four signs are summarized in Table 6. As can be seen from this table, among the Spanish-speaking drivers in the border sample, the overall comprehension levels for all four signs were in the 60 to 65 percent range. Among the English-speaking drivers in the border sample, there was a large difference in comprehension between the English-legend and Spanish-legend signs, with the English-legend signs having comprehension levels around 90 percent, while the Spanish-legend signs had comprehension levels of between 50 and 60 percent. Comprehension for the English-legend signs among the non-border sample was similar to that of the English-speaking drivers in the border sample (about 90 percent).

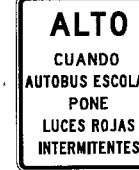
Table 7 indicates the relative performance of the four school bus signs among Spanish-speaking drivers. Of particular importance in this table is an indication that none of the three alternatives is statistically better than the standard sign. The results for the standard sign showed a comprehension level of 65 percent. The English-legend alternative, **Stop for School Bus When Red Lights Flashing**, had a slightly higher correct response percentage, 66 percent, but the results of the z-test showed that the difference was not statistically significant. Each of the two Spanish-legend signs, **Alto Cuando Autobus Escolar Pone Señales Rojas Destellando** and **Alto Cuando Autobus Escolar Pone Luces Rojas Intermitentes**, had comprehension levels that were similar to those for the standard sign, with 63 percent and 65 percent, respectively.

Table 6. Summary of Results for School Bus Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size
STOP FOR SCHOOL BUS LOADING OR UNLOADING	25.8%	39.2%	217	31.4%	56.9%	51	45.0%	42.3%	111
	C+PC=65.0%			C+PC=88.2%			C+PC=87.3%		
STOP FOR SCHOOL BUS WHEN RED LIGHTS FLASHING	27.7%	38.5%	213	40.0%	51.1%	45	52.1%	36.8%	117
	C+PC=66.2%			C+PC=91.1%			C+PC=88.9%		
ALTO CUANDO AUTOBUS ESCOLAR PONE SENALES ROJAS DESTELLANDO	27.8%	35.4%	209	19.2%	40.4%	52	N/A		
	C+PC=61.7%			C+PC=59.6%					
ALTO CUANDO AUTOBUS ESCOLAR PONE LUCES ROJAS INTERMITENTES	32.5%	32.5%	212	22.9%	29.2%	48	N/A		
	C+PC=65.1%			C+PC=52.1%					

Note: C+PC is the sum of the correct and partially correct response rates.
Response rates reflect responses to primary question.

Table 7. Comparison of Alternatives for the School Bus Signs

Device				
Comprehension Level ¹	65.0%	66.2%	63.2%	65.1%
Confidence Interval ²	±5.3%	±5.3%	±5.5%	±5.4%
Sample Size ³	217	213	209	212
Statistical Significance ⁴	N/A	No	No	No

Notes: ¹ Percentage of correct plus partially correct responses.

² Based on a 90% confidence level.

³ Sample size for Spanish-speaking drivers in border surveys.

⁴ Determination of whether an alternative was statistically better than the standard sign.

Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Fasten Safety Belts Sign

All three of the alternative versions of the **Fasten Safety Belts – State Law** sign (R19-8) utilized Spanish legends. Table 8 presents the survey questions and response concepts used in the evaluation of the standard sign and alternatives.

The results of the third-year surveys are presented in Table 9. As can be seen from this table, there were some obvious differences in comprehension levels between signs and between driver samples. Among the English-speaking border and non-border driver sample, the standard sign (English-legend) had an overall comprehension level of over 95 percent. Among the Spanish-speaking border driver sample, the overall comprehension levels for the three Spanish-legend signs were over 95 percent. In comparison, the overall comprehension level for the English-legend sign was about 77 percent for the Spanish-speaking driver sample and the overall comprehension level for the Spanish-legend signs was approximately 65 to 75 percent for the English-speaking border drivers.

Table 10 indicates the relative performance in overall comprehension levels for the four signs among the Spanish-speaking driver sample. It includes a statistical comparison that indicates that all three of the alternative signs are statistically better understood than the English-legend standard sign. None of the alternatives is statistically better than another alternative. The closeness in value of the comprehension levels for the Spanish-legend signs is not surprising as the Spanish legends were quite similar. There is only one way to say “seat belt” or “safety belt” in Spanish, “el cinturón de seguridad.” Therefore, the only difference in the legends was the word used to translate the verb “to fasten.”

Table 8. Questions and Response Concepts for Fasten Safety Belts Signs

Primary and Follow-Up Questions		Correct Response Concept	Partially Correct Response Concept
Fasten Safety Belts Signs (R19-8)		FASTEN SAFETY BELTS STATE LAW ASEGURESE EL CINTURON DE SEGURIDAD LEY ESTATAL ABROCHESE EL CINTURON DE SEGURIDAD LEY ESTATAL PONGASE EL CINTURON DE SEGURIDAD LEY ESTATAL	
What does this sign mean?		Must wear safety/seat belt and it is state law	Verbatim ¹ , safety/seat belt or wear safety/seat belt
Follow-up	Why is this sign important?	Safety, protection, in case of an accident, or state law	None

Note: ¹A verbatim response is one in which the survey respondent simply read the sign legend out loud without providing any additional explanation.

Table 9. Summary of Results for Fasten Safety Belts Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size
FASTEN SAFETY BELTS STATE LAW	10.0%	66.8%	190	5.9%	90.2%	51	23.2%	76.3%	228
	C+PC=76.8%			C+PC=96.1%			C+PC=99.5%		
ASEGURESE EL CINTURON DE SEGURIDAD LEY ESTATAL	11.1%	84.3%	198	6.1%	65.3%	49	N/A		
	C+PC=95.5%			C+PC=71.4%					
ABROCHESE EL CINTURON DE SEGURIDAD LEY ESTATAL	7.5%	87.9%	199	2.0%	73.5%	49	N/A		
	C+PC=95.5%			C+PC=75.5%					
PONGASE EL CINTURON DE SEGURIDAD LEY ESTATAL	8.7%	87.4%	207	9.1%	54.5%	44	N/A		
	C+PC=96.1%			C+PC=63.6%					

Note: C+PC is the sum of the correct and partially correct response rates.
Response rates reflect responses to primary question.

Table 10. Comparison of Alternatives for the Fasten Safety Belts Signs

Device				
Comprehension Level ¹	76.8%	95.5%	95.5%	96.1%
Confidence Interval ²	±5.0%	±2.4%	±2.4%	±2.2%
Sample Size ³	190	198	199	207
Statistical Significance ⁴	N/A	Yes	Yes	Yes

Notes: ¹ Percentage of correct plus partially correct responses.

² Based on a 90% confidence level.

³ Sample size for Spanish-speaking drivers in border surveys.

⁴ Determination of whether an alternative was statistically better than the standard sign.

Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Right Lane Ends Sign

As with the previous sign, there were three Spanish-legend alternatives to the **Right Lane Ends** (W9-2) standard sign. Table 11 identifies the signs, questions, and response concepts for this set of signs.

Table 11. Questions and Response Concepts for Right Lane Ends Signs

Primary and Follow-Up Questions		Correct Response Concept	Partially Correct Response Concept
Right Lane Ends Signs (W9-1)		   	
What does this sign mean?		Right lane ends or move to the left lane	Verbatim ¹
Follow-up	What would you do if you saw this sign in the road?	Change lanes or move left	None

Note: ¹A verbatim response is one in which the survey respondent simply read the sign legend out loud without providing any additional explanation.

The results of the third-year surveys are summarized in Table 12. As can be seen from this table, the English-legend signs had a high overall comprehension level among the English-speaking driver sample, while the Spanish-legend signs had a higher overall comprehension level among the Spanish-speaking driver sample than the English-legend signs. Among the English-speaking drivers, the standard sign had overall comprehension levels over 90 percent. Among Spanish-speaking drivers, the Spanish-legend signs had comprehension levels near 85 percent. When a sign was presented to a driver in the non-native language, the overall comprehension levels were much lower. The standard (English) sign was understood by 69 percent of the Spanish-speaking drivers while the Spanish-legend alternatives had overall comprehension levels between 34 and 63 percent among the English-speaking drivers.

Table 13 presents a statistical comparison of the performance of the signs, among the Spanish-speaking driver sample. All three of the Spanish-legend signs were statistically better understood than the standard sign. None of the alternatives were statistically better than any other alternative, although the CARRIL DERECHO TERMINA had the highest comprehension level.

Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Table 12. Summary of Results for Right Lane Ends Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size
	66.7%	2.1%	192	95.9%	4.1%	49	77.2%	15.4%	228
	C+PC=68.8%			C+PC=100.0			C+PC=92.6%		
	76.2%	12.2%	189	62.7%	0.0%	51	N/A		
	C+PC=88.4%			C+PC=62.7%					
	74.2%	9.1%	198	59.6%	0.0%	52	N/A		
	C+PC=83.3%			C+PC=59.6%					
	74.7%	10.5%	190	34.0%	0.0%	50	N/A		
	C+PC=85.3%			C+PC=34.0%					

Note: C+PC is the sum of the correct and partially correct response rates.
Response rates reflect responses to primary question.

Table 13. Comparison of Alternatives for the Right Lane Ends Signs

Device				
Comprehension Level ¹	68.8%	88.4%	83.3%	85.3%
Confidence Interval ²	±5.5%	±3.8%	±4.4%	±4.2%
Sample Size ³	192	189	198	190
Statistical Significance ⁴	N/A	Yes	Yes	Yes

Notes: ¹ Percentage of correct plus partially correct responses.

² Based on a 90% confidence level.

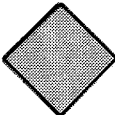
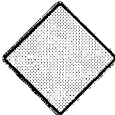
³ Sample size for Spanish-speaking drivers in border surveys.

⁴ Determination of whether an alternative was statistically better than the standard sign.

Sign Color and Shape

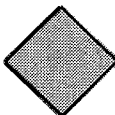
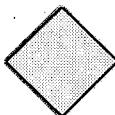
At the beginning of the survey, each driver was presented a blank sign that showed a standard color and shape. The driver was asked what a sign with that shape meant. Table 14 identifies the sign shape/color, question, and response concepts.

Table 14. Questions and Response Concepts for Sign Shape and Color

Primary and Follow-Up Questions	Correct Response Concept	Partially Correct Response Concept
Sign Shape and Color	   Orange Yellow White	
What does a sign with this shape mean?	Orange - construction Yellow - warning, caution, hazard White - yield, ceda el paso	None

The results of the third-year surveys are summarized in Table 15. As can be seen from this table, drivers in the survey samples have a low understanding of some of the basic elements of the sign shape and color code. Only the Yield sign shape had comprehension levels over 50 percent. Appendices A and B present additional detail regarding driver responses to questions about these signs.

Table 15. Summary of Passenger Car Driver Results for Right Lane Ends Signs

Sign	BORDER				NON-BORDER	
	Spanish Language		English or Both Languages		English Language	
	Correct	Sample Size	Correct	Sample Size	Correct	Sample Size
 Orange	7.1%	182	21.6%	51	9.9%	111
 Yellow	32.4%	182	41.5%	53	N/A	N/A
 White	49.5%	186	76.0%	50	82.9%	117

Note: There was no partially correct response for this sign.

Results of Truck Driver Surveys

The results for the truck driver surveys are presented in the following sections in a manner that is consistent with that used for the passenger car survey. In the truck driver survey, three standard traffic signs and three alternatives for each sign were evaluated. The signs included in this survey had messages intended specifically for truck drivers.

The border surveys were administered to a total 315 drivers at the Columbia-Solidarity international bridge crossing in Laredo and the Pharr Bridge in McAllen. Among the border truck drivers in the survey sample, there were very few that indicated that English was the primary language spoken at home. Therefore, the sample size of English-speaking drivers for the border truck driver survey is very small. In all cases, it was less than five drivers for any given sign/alternative. As a result of the small sample sizes, the response percentages for the English-speaking truck drivers should not be considered as representative of English-speaking truck drivers.

The non-border survey was administered to 210 drivers at a weigh station on I.H. 35 near Kyle. As with the passenger car driver survey, each truck driver saw only one of the four survey sets, and no driver was shown more than one alternative for each sign.

Weigh Station Sign

Four different versions of the **Weigh Station Next Right** (D8-2) sign were included in the truck driver survey. The standard sign was the only English-language sign. The three alternatives were all Spanish-language signs. Table 16 presents the signs, questions, and response concepts associated with these four signs.

Table 16. Questions and Response Concepts for Weigh Station Signs

Question		Correct Response Concept	Partially Correct Response Concept
Weigh Station Signs (D8-2)		   	
What does this sign mean?		Weigh station is open and trucks must stop to be weighed	Verbatim ¹ , weigh station is open, or trucks must stop to be weighed
Follow-up	What would you do if you saw this sign in the road?	Pull over, stop, or get weighed	None

Note: ¹A verbatim response is one in which the survey respondent simply read the sign legend out loud without providing any additional explanation.

The results of the third-year surveys for these signs are shown in Table 17. The signs in this table were not presented to truck drivers in the non-border survey, as that survey was conducted at a weigh station. As indicated previously, the sample size of English-speaking truck drivers is

too small to be representative of the population. Among the Spanish-speaking truck driver sample, the English-language standard sign had an overall comprehension level of 19 percent. The first Spanish-legend sign, **Estacion De Pesaje - Proxima Derecha**, performed moderately better than the standard sign; 28 percent of the truck drivers understood the intended message. The next two Spanish-legend signs showed further improvement over the standard sign. **Estacion De Pesado - Proxima Derecha** had a comprehension level of 38 percent, and the final alternative, **Bascula - Proxima Derecha**, showed a correct response rate of 44 percent.

Table 17. Summary of Results for Weigh Station Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size ¹	Correct	Partially Correct	Sample Size
WEIGH STATION NEXT RIGHT OPEN	1.4%	17.4%	69	0.0%	66.7%	3	N/A ²		
	C+PC=18.8%			C+PC=66.7%					
ESTACION DE PESADO PROXIMA DERECHA ABIERTO	1.4%	29.2%	72	0.0%	0.0%	3	N/A		
	C+PC=30.6%			C+PC=0.0%					
BASCUA PROXIMA DERECHA ABIERTO	2.9%	39.1%	69	0.0%	0.0%	2	N/A		
	C+PC=42.0%			C+PC=0.0%					
ESTACION DE PESAJE PROXIMA DERECHA ABIERTO	6.8%	39.2%	74	N/A	N/A	0	N/A		
	C+PC=45.9%			N/A					

Note: C+PC is the sum of the correct and partially correct response rates.

Response rates reflect responses to primary question.

¹Sample size is too small to be representative of the population.

²This sign was not included in the non-border survey as it was conducted at a weigh station.

Table 18 compares the relative performance of the four signs among the Spanish-speaking truck drivers at the border location. As can be seen from this table, the **Estacion De Pesado - Proxima Derecha** was not statistically better than the standard **Weigh Station - Next Right** sign. However, the other two Spanish-language signs, **Bascula - Proxima Derecha** and **Estacion De Pesaje - Proxima Derecha**, were both statistically better understood than the standard sign.

Table 18. Comparison of Alternatives for the Weigh Station Signs

Device	WEIGH STATION NEXT RIGHT OPEN	ESTACION DE PESADO PROXIMA DERECHA ABIERTO	BASCULA PROXIMA DERECHA ABIERTO	ESTACION DE PESAJE PROXIMA DERECHA ABIERTO
Comprehension Level ¹	18.8%	30.6%	42.0%	45.9%
Confidence Interval ²	±7.7%	±8.9%	±9.8%	±9.5%
Sample Size ³	69	72	69	74
Statistical Significance ⁴	N/A	No	Yes	Yes

Notes: ¹ Percentage of correct plus partially correct responses.

² Based on a 90% confidence level.

³ Sample size for Spanish-speaking drivers in border surveys.

⁴ Determination of whether an alternative was statistically better than the standard sign.

Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Weight Limit Sign

The Weight Limit sign was presented in four versions: the standard English-language sign (R12-1), and three Spanish-language alternatives. Table 19 presents the signs, questions, and response concepts associated with these four signs.

Table 19. Questions and Response Concepts for Weight Limit Signs

Question		Correct Response Concept	Partially Correct Response Concept
Weight Limit Signs (R12-1)		   	
What does this sign mean?		Maximum weight or weight limit and ten tons	Verbatim ¹ , maximum weight or weight limit, or ten tons
Follow-up	Why is this sign used?	Bridge limit, road limit, or to restrict overweight vehicles	None
	Does the limit refer to the total weight or the weight per axle?	Total Weight	None
	How much is a ton?	2000 pounds or 980 kilograms	None

Note: ¹A verbatim response is one in which the survey respondent simply read the sign legend out loud without providing any additional explanation.

The results of the third-year surveys on this sign are provided in Table 20. As indicated previously, the sample of English-speaking border truck drivers is too small to be representative of the population. The standard sign was very well understood by the non-border drivers (98 percent overall comprehension level). The Spanish-language signs (**Limite De Peso - 10 Tons**, **Peso Limitado - 10 Tons**, and **Peso Maximo - 10 Tons**) were well understood by the border drivers (90-95 percent overall comprehension levels). In comparison, the English-language sign was understood by 75 percent of the sample of border truck drivers speaking Spanish.

Table 20. Summary of Results for Weight Limit Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size ¹	Correct	Partially Correct	Sample Size
WEIGHT LIMIT 10 TONS	40.0%	34.7%	75	0.0%	100.0%	3	13.3%	84.8%	210
	C+PC=74.7%			C+PC=100.0%			C+PC=98.1%		
LIMITE DE PESO 10 TONS	42.1%	52.6%	76	50.0%	0.0%	2	N/A		
	C+PC=94.7%			C+PC=50.0%					
PESO LIMITADO 10 TONS	54.2%	37.5%	72	50.0%	0.0%	2	N/A		
	C+PC=91.7%			C+PC=50.0%					
PESO MAXIMO 10 TONS	64.9%	28.4%	74	N/A	N/A	0	N/A		
	C+PC=93.2%			N/A					

Note: C+PC is the sum of the correct and partially correct response rates.

Response rates reflect responses to primary question.

¹Sample size is too small to be representative of the population.

Table 21 provides a statistical comparison of the relative performance of the four signs. All three of the Spanish-language signs were statistically better understood than the standard sign. Although the **Limite De Peso - 10 Tons** sign had the highest overall comprehension level, it was not statistically better than that for the other two Spanish-language signs. Furthermore, the difference between the high and low overall comprehension levels was 3 percent. The correct response rate for the **Peso Maximo** sign was statistically significantly better than that for the

Limite De Peso sign, but not the **Peso Limitado** sign. The difference between the best and second best correct response rates was 10.7 percent.

Table 21. Comparison of Alternatives for the Weight Limit Signs

Device	WEIGHT LIMIT 10 TONS	LIMITE DE PESO 10 TONS	PESO LIMITADO 10 TONS	PESO MAXIMO 10 TONS
Comprehension Level ¹	74.7%	94.7%	91.7%	93.2%
Confidence Interval ²	±8.3%	±4.2%	±5.3%	±4.8%
Sample Size ³	75	76	72	74
Statistical Significance ⁴	N/A	Yes	Yes	Yes

Notes: ¹ Percentage of correct plus partially correct responses.

² Based on a 90% confidence level.

³ Sample size for Spanish-speaking drivers in border surveys.

⁴ Determination of whether an alternative was statistically better than the standard sign.

Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Load Zoned Bridge Sign

As with the other signs, there were four versions of the Load Zoned Bridge sign (W12-5) in the truck driver survey. However, unlike the other truck driver survey signs, one of the alternatives was an English-language sign. This provided two English- and two Spanish-language signs in the survey. Table 22 presents the signs, questions, and response concepts associated with these four signs.

Table 22. Questions and Response Concepts for Load Zoned Bridge Signs

Question		Correct Response Concept	Partially Correct Response Concept
Load Zoned Bridge Signs (W12-5)			
What does this sign mean?		Weight limit and bridge	Verbatim ¹ , weight limit, or bridge
Follow-up	What would you do if you saw this sign in the road?	Look for posted weight limit or compare truck weight with posted limit	Stop, turn around, or find another road (with no further explanation)

Note: ¹A verbatim response is one in which the survey respondent simply read the sign legend out loud without providing any additional explanation.

Table 23 presents the results of the truck driver surveys for these four signs. Among the Spanish-speaking drivers, the standard English-language sign (LOAD ZONED BRIDGE) had a comprehension level of 25 percent. The alternative English-language sign (BRIDGE LIMIT) was almost twice as well understood, while both of the Spanish-language signs had overall comprehension levels over 90 percent.

Table 23. Summary of Results for Load Zoned Bridge Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size ¹	Correct	Partially Correct	Sample Size
	2.8%	22.5%	71	33.3%	33.3%	3	62.3%	35.8%	106
	C+PC=25.4%			C+PC=66.7%			C+PC=98.1%		
	2.8%	38.9%	72	0.0%	66.7%	3	61.5%	34.6%	104
	C+PC=41.7%			C+PC=66.7%			C+PC=96.1%		
	1.3%	89.3%	75	0.0%	100.0%	1	N/A		
	C+PC=90.7%			C+PC=100.0%					
	48.7%	50.0%	76	N/A	N/A	0	N/A		
	C+PC=98.7%			N/A					

Note: C+PC is the sum of the correct and partially correct response rates.

Response rates reflect responses to primary question.

¹Sample size is too small to be representative of the population.

Table 24 compares the relative performance of the standard and alternative signs evaluated in the surveys. As the table indicates, all three of the alternatives were better understood than the standard sign.

Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Table 24. Comparison of Alternatives for the Load Zoned Bridge Signs

Device				
Comprehension Level ¹	25.4%	41.7%	90.7%	98.7%
Confidence Interval ²	±8.5%	±9.6%	±5.5%	±2.1%
Sample Size ³	71	72	75	76
Statistical Significance ⁴	N/A	Yes	Yes	Yes

Notes: ¹ Percentage of correct plus partially correct responses.

² Based on a 90% confidence level.

³ Sample size for Spanish-speaking drivers in border surveys.

⁴ Determination of whether an alternative was statistically better than the standard sign.

Hazardous Cargo Signing

The Hazardous Cargo Route (R14-2) and Hazardous Cargo Prohibited (R14-3) signs had been found in the previous surveys to have very low comprehension levels. The third-year survey included the standard Hazard Cargo Route sign and two alternatives to that sign, plus one alternative to the Hazardous Cargo Prohibited sign. The standard Hazardous Cargo Prohibited sign was not included in the survey. Table 25 presents the signs, questions, and response concepts that were associated with these signs.

Table 25. Questions and Response Concepts for Hazardous Cargo Signs

Question		Correct Response Concept	Partially Correct Response Concept
Hazardous Cargo Signs (R14-2 and R14-3)		 	 
What does this sign mean?		Hazardous cargo/material is permitted/prohibited	Hazardous cargo/material is permitted or prohibited
Follow-up	What does the symbol inside the circle mean?	Hazardous cargo or hazardous material	None

Table 26 displays the results of the third-year surveys for these signs. As can be seen from this table, the overall comprehension level for these signs among the Spanish-speaking driver sample was low (less than 15 percent). Comprehension was significantly higher among the non-border drivers, with overall comprehension levels near 80 percent for the signs that used HC or HM in the legend. Understanding of the NFPA sign was much lower in the third-year surveys than it had been in the second-year survey.

Table 26. Summary of Results for Hazardous Cargo Signs

Sign	BORDER						NON-BORDER		
	Spanish Language			English or Both Languages			English Language		
	Correct	Partially Correct	Sample Size	Correct	Partially Correct	Sample Size ¹	Correct	Partially Correct	Sample Size
	1.5%	3.0%	66	50.0%	0.0%	2	18.9%	60.4%	53
	C+PC=4.5%			C+PC=50.0%			C+PC=79.3%		
	1.5%	10.6	66	0.0%	0.0%	1	7.5%	30.2%	53
	C+PC=12.1%			C+PC=0.0%			C+PC=37.7%		
	1.5%	3.0%	67	0.0%	0.0%	1	9.6%	71.2%	52
	C+PC=4.5%			C+PC=0.0%			C+PC=80.8%		
	0.0%	1.5%	66	N/A	N/A	0	36.5%	44.2%	52
	C+PC=1.5%			N/A			C+PC=80.7%		

Note: C+PC is the sum of the correct and partially correct response rates.

Response rates reflect responses to primary question.

¹Sample size is too small to be representative of the population.

Because of the low comprehension levels for the permitted sign, it is not appropriate to compare the relative performance of the alternatives. Appendices A and B present additional detail regarding driver responses to questions about these signs. These include response rates for the primary and follow-up questions, plus response rates for key word concepts.

Sign Shape and Color

At the beginning of the survey, each driver was presented a blank sign that showed a standard color and shape. The driver was asked what a sign with that shape meant. Table 27 identifies the sign shape/color, question, and response concepts. The question was identical to that used in the passenger car survey. The yellow diamond was not presented to truck drivers at the non-border location.

The results of the third-year surveys are summarized in Table 28. As can be seen from this table, drivers in the survey samples have a low understanding of some of the basic elements of the sign shape and color code. It should be noted that the sample size for English-speaking or bilingual drivers for the border survey is too small to be meaningful. Only the Yield sign shape

had comprehension levels over 50 percent. Appendices A and B present additional detail regarding driver responses to questions about these signs.

Table 27. Questions and Response Concepts for Sign Shape and Color

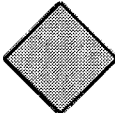
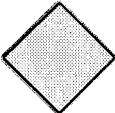
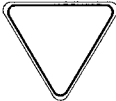
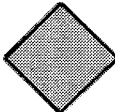
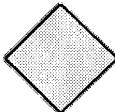
Primary and Follow-Up Questions	Correct Response Concept	Partially Correct Response Concept
Sign Shape and Color	   Orange Yellow White	
What does a sign with this shape mean?	Orange - construction Yellow - warning, caution, hazard White - yield, ceda el paso	None

Table 28. Summary of Truck Driver Results for Sign Shape and Color

Sign	BORDER				NON-BORDER	
	Spanish Language		English or Both Languages		English Language	
	Correct	Sample Size	Correct	Sample Size	Correct	Sample Size
 Orange	3.5%	57	0.0%	2	30.2%	106
 Yellow	21.1%	57	50.0%	2	N/A	N/A
 White	39.7%	58	N/A	0	86.5%	104

Note: There was no partially correct response for this sign.

CHAPTER 4

SUMMARY OF FINDINGS

During the third year of this research project, 1,869 drivers were surveyed to assess how well they understood a small sample of signs. These signs included both standard and alternative designs of signs that had been identified in previous years of the research project as potential candidates for improvement. The survey also included a question on different sign shapes and colors. Table 29 summarizes the signs that were included in the different surveys.

The passenger car survey was administered at both border and non-border locations. The border survey locations were at international bridges between Texas and Mexico. The non-border survey locations were Driver License Stations in Houston and Bryan. There were 1,116 participants in the border passenger car survey and 228 in the non-border survey. The survey addressed three sign concepts, plus some elements of the sign shape and color code.

The truck survey was administered at both border and non-border locations. The border locations were also at international bridges between Texas and Mexico. The non-border location was a weigh station along the Interstate in central Texas. There were 315 participants in the border truck survey and 210 in the non-border survey. The survey addressed four sign concepts, plus some elements of the sign shape and color code.

This chapter summarizes the results presented in the previous chapter and identifies whether any of the alternatives had comprehension levels that indicate the alternative should be used in place of, or as a supplement to, the standard sign.

The overall recommendations resulting from this research project are presented in a separate report (3). These recommendations incorporate findings from all three years of the research project and address many signs that were not a part of the third-year evaluations.

PASSENGER CAR DRIVER SURVEY RESULTS

The passenger car survey addressed three signs with word message legends—Stop for School Bus Loading or Unloading, Fasten Safety Belts State Law, and Right Lane Ends. These signs were selected for evaluation because the findings from previous years of the research effort had indicated a potential for improving comprehension.

Stop for School Bus Sign

State law in Texas requires drivers to stop for a school bus whenever it is loading or unloading passengers. The law also requires buses to flash red lights whenever loading or unloading is taking place. This sign was included in the survey to determine how well the current sign communicates that message.

Table 29. Signs Evaluated in Third Year of Research

Population	Sign Name	Standard Design	Alternative 1	Alternative 2	Alternative 3
Passenger Cars	Stop for School Bus				
	Fasten Safety Belts				
	Right Lane Ends				
Trucks	Weigh Station				
	Weight Limit				
	Load Zoned Bridge				
	Hazardous Cargo				
Both	Sign Shape/Color	 Orange	 Yellow	 White	

Border Results

The results of the survey showed that none of the three alternatives to the Stop for School Bus Loading or Unloading sign demonstrated a significant improvement in comprehension over the standard sign. Therefore, none of the alternatives appear to be effective replacements or supplements to the standard signs in the border area. The alternative English legend, **Stop for School Bus When Red Lights Flashing**, had an overall comprehension level that was slightly higher than that for the standard sign, but the difference is not statistically significant.

Non-Border Results

The overall comprehension levels (correct plus partially correct) for the two English-legend signs were very close to one another. The difference was less than 2 percent with the **Stop for School Bus When Red Lights Flashing** having the higher level. There was no statistically significant difference between the overall comprehension levels for the two signs. The correct comprehension level for the **Stop for School Bus When Red Lights Flashing** sign was about 7 percent higher than the standard sign.

Third-Year Recommendation

Based on the data collected during the third year of this research effort, none of the alternatives evaluated are sufficiently better than the standard sign to justify implementation of an alternative.

Fasten Safety Belts Sign

State law in Texas requires drivers to wear their safety (seat) belt while driving. The standard sign and Spanish-language alternatives were evaluated in the third year to determine how well the sign communicates the intended message.

Border Results

Each of the three Spanish-legend signs outperformed the standard sign by almost 20 percent, a difference that was statistically significant for all of the alternatives. Overall comprehension levels for the three signs were approximately 95 percent. As the three legends are quite similar, it is doubtful that further research will show one to be significantly better than the other two.

Non-Border Results

The standard sign was found to have a high comprehension level. Worth noting is that a higher percentage of people responded with “seat belt” rather than “safety belt” despite the fact that “safety belt” appears on the sign. No alternatives were evaluated in the non-border survey.

Third-Year Recommendation

Based on the data collected during the third year of this research effort, it is recommended that the Spanish-legend sign which had the highest overall and correct response rates (95.5 percent overall and 11.1 percent correct among Spanish-speaking border drivers), **Asegurese El Cinturon De Seguridad – Ley Estatal**, be used to supplement the standard sign when engineering judgement indicates safety or compliance concerns in a border district. The sign may be installed on the same signpost adjacent to the standard sign or downstream of the standard sign.

Right Lane Ends Sign

There are three signs that are used to inform drivers of a lane ending situation. Two are word message signs, and the primary sign is a symbol sign. All three signs have been evaluated in previous TTI research (6). The findings from the previous research led to the Right Lane Ends sign being included in the border research effort.

Border Results

The survey results indicated that all three of the alternative signs had higher overall comprehension levels than the standard sign. Each of the alternatives was 15 to 20 percent better than the standard sign, a difference that was statistically significant. Overall comprehension levels for the three signs ranged from 83 to 88 percent. Of the three Spanish-legend alternatives, **Carril Derecho Termina** had the highest overall comprehension level, compared to the standard sign. This sign also had the highest overall comprehension of the three Spanish-legend signs among the English-speaking border drivers.

Non-Border Results

The standard sign was found to have an overall comprehension level over 90 percent. No alternatives were evaluated.

Third-Year Recommendation

Based on the data collected during the third year of this research effort, it is recommended that the Spanish-legend sign which had the highest comprehension level (88.4 percent), **Carril Derecho Termina**, be used to supplement the standard sign when engineering judgement indicates safety or compliance concerns in a border district. The sign may be installed downstream of the standard sign.

Sign Shape and Color Code

Previous TTI research (6) has shown that many drivers do not fully understand the meaning of various sign shapes and colors. Since this issue had not been addressed with Texas border drivers, several sign shapes/colors were included in the third-year survey.

Border Results

The results for the passenger car survey on sign shape and color indicated a generally poor understanding of the meaning of yellow and orange diamond-shaped signs. Comprehension levels were less than 50 percent. The recognition of the triangular yield shape was higher, with 50 percent of the Spanish-speaking drivers and 76 percent of the English-speaking drivers indicating the proper response.

Non-Border Results

Although the yellow diamond was not included in the non-border survey, the low comprehension levels for the orange diamond indicate a general lack of understanding of construction warning sign color that is likely to extend to general warning signs. However, recognition of the yield shape was higher than for any other shape, with 83 percent indicating the proper meaning.

Third-Year Recommendation

Driver understanding of the sign color and shape code is not likely to be improved through changes in the design of signs. Instead, it is an issue that must be addressed in driver training activities. Based on the data collected during the third year of this research effort, it is recommended that sign shapes and colors receive emphasis in any driver training and/or outreach efforts that are conducted in the border areas.

TRUCK DRIVER SURVEY RESULTS

The truck driver survey addressed three signs with word message legends (Weigh Station, Weight Limit, and Load Zoned Bridge), hazardous cargo signs (both permitted and prohibited), and the same sign shape and color issues addressed in the passenger car survey. All of the signs except for the hazardous cargo signs related to weight limits in some fashion.

Weigh Station Sign

Weigh stations are used to ensure that heavy vehicles traveling on the highway do not exceed the state laws regarding weight limits. The findings from the previous years of this research indicated good potential for improving comprehension of this sign through Spanish-language alternative designs.

Border Results

Two of the Spanish-language alternative signs (**Bascula – Proxima Derecha** and **Estacion De Pesaje – Proxima Derecho**) were found to be better understood than the standard sign and the other Spanish-language alternative. The two signs had very similar overall comprehension levels.

Non-Border Results

The non-border truck driver survey was conducted at a weigh station. Therefore, the researchers did not include this sign in the survey.

Third-Year Recommendation

Based on the findings of the third-year evaluations, there is little basis to indicate which of the two Spanish-language signs should be recommended. Although the **Estacion De Pesaje** sign had a higher correct response rate, the difference is less than 4 percent.

Weight Limit Sign

A weight limit sign was included in the survey because of the fact that Mexico allows heavier vehicles on their highways than are permitted in Texas. One of the concerns was whether Mexican truck drivers would understand weight limits indicated by signs. In addition to the standard sign, three Spanish-language alternative signs were evaluated.

Border Results

The border survey results indicated that all three of the alternative signs had higher comprehension levels than the standard sign. The extent of the improvement ranged from 15 to 20 percent, all of which were statistically significant. The sign with the highest overall comprehension level (correct plus partially correct) was **Limite De Peso 10 Tons**. However, the sign with the highest correct response rate was **Peso Maximo - 10 Tons**. Furthermore, while the difference in overall comprehension levels for the three Spanish-language signs was 3 percent or less, the difference in the correct response rates was much greater.

Non-Border Results

A significant percentage of non-border drivers was able to convey the correct concept of a limit and maximum weight. Interestingly, a large percentage of drivers associated this sign with a weak bridge as evidenced by the “bridge limit” response to the follow-up question.

Third-Year Recommendation

Based on the data collected during the third year of this research effort, it is recommended that the Spanish-legend sign which had the highest correct response rate (64.9 percent), **Peso Maximo**, be used to supplement the standard sign when engineering judgement indicates safety or compliance concerns in a border district. The sign may be installed downstream of the standard sign.

Load Zoned Bridge Sign

This sign was included to assess understanding of the message providing advance notice of a weight restricted bridge. Two Spanish-language alternatives and one English-language alternative were evaluated along with the standard sign.

Border Results

Third-year comprehension of the standard sign and alternatives as a group was lower than for any other group of signs except the hazardous cargo signs. Only one of the signs (**Puente De Peso Limitado**) had correct response rates over 10 percent. The two Spanish-language signs both had overall comprehension levels greater than 90 percent.

Non-Border Results

The standard sign with the unique legend **Load Zoned Bridge** (W12-5) has a relatively high comprehension rate in non-border areas. Both the standard sign and the **Bridge Limit** alternative sign had similar comprehension levels, with the standard sign having slightly higher levels.

Third-Year Recommendation

Based on the data collected during the third year of this research effort, it is recommended that the Spanish-legend sign, **Puente De Peso Limitado**, be used to supplement the standard sign when engineering judgement indicates safety or compliance concerns in a border district. The sign may be installed downstream of the standard sign or on the same post.

Hazardous Cargo Signs

Throughout the course of the research project, the researchers consistently identified low comprehension levels for the hazardous cargo signs. During the third-year evaluations, several different alternatives were evaluated. All of the signs are classified as symbol signs, although several use the initials HC or HM.

Border Results

Neither the standard hazardous cargo sign nor any of the alternatives were understood by the border truck drivers. The standard sign had a comprehension level of only 5 percent. The best of the alternatives had an overall comprehension level of only 12 percent.

Non-Border Results

Comprehension of the **Hazard Cargo Route** sign was much higher in the non-border survey than in any of the previous border evaluations conducted as part of this research effort. The overall comprehension level for the three signs using HC/HM initials was near 80 percent.

Third-Year Recommendation

None of the results of the third-year evaluations indicate any alternatives that can be used to replace or supplement the standard sign. These signs should be emphasized in future truck driver training/outreach efforts.

Sign Shape and Color Code

Sign shape and color the only questions that were included in both the passenger car and truck driver surveys in the third-year evaluations.

Border Results

As with the passenger car evaluation, the results for the truck driver survey on sign shape and color indicated a generally poor understanding of the meaning of yellow and orange diamond-shaped signs. Comprehension levels were less than 50 percent. The recognition of the triangular yield shape was higher, with 40 percent of the Spanish-speaking drivers indicating the proper response.

Non-Border Results

Although the yellow diamond was not included in the non-border survey, the low comprehension levels for the orange diamond indicate a general lack of understanding of construction warning sign color that is likely to extend to general warning signs. However, recognition of the yield shape was higher than for any other shape, with 87 percent indicating the proper meaning.

Third-Year Recommendation

Driver understanding of the sign color and shape code is not likely to be improved through changes in the design of signs. Instead, it is an issue that must be addressed in driver training activities. Based on the data collected during the third year of this research effort, it is recommended that sign shapes and colors receive emphasis in any driver training and/or outreach efforts that are conducted in the border areas.

CHAPTER 5

REFERENCES

1. Hawkins, Jr., H.G., D.L. Picha, B.L. Mann, C.R. McIlroy, K.N. Womack, and C.L. Dudek. *Assessment of Mexican Driver Understanding of Existing Traffic Control Devices Used in Texas*, Research Project 1274-1, Texas Transportation Institute, College Station, Texas, November 1996.
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APPENDIX A

DETAILED SURVEY RESULTS

This appendix presents the detailed survey results for the border and non-border survey results by the type of sign. The response rates indicated in these tables are based upon the total sample size for each question, which includes the indeterminate responses. Therefore, the response rates shown in this appendix may not correspond to those presented in Chapter 3. For the border sample, the response rates represent both Spanish- and English-speaking drivers (the entire border sample).

Table 30. Border Survey Results for School Bus Signs

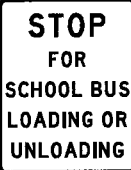
Primary Question		What does this sign mean?						
Follow-up Question 1		When do you have to stop for a school bus?						
Follow-up Question 2		Why do you have to stop for a school bus?						
Follow-up Question 3		Does traffic in both directions have to stop?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	0.0	26.8	42.4	29.7	0.7	0.4	269
	Follow-up 1	19.3	67.7	0.0	10.8	0.0	2.2	269
	Follow-up 2	46.1	50.9	0.0	2.2	0.0	0.7	269
	Follow-up 3	50.6	42.4	0.0	5.6	1.5	0.0	269
	Primary	0.0	29.7	40.2	26.7	2.6	0.8	266
	Follow-up 1	30.5	55.6	0.0	11.3	0.0	2.6	266
	Follow-up 2	37.6	60.2	0.0	1.1	0.0	1.1	266
	Follow-up 3	48.1	43.2	0.0	6.4	0.8	1.5	266
	Primary	0.0	25.6	35.7	32.3	4.5	1.9	266
	Follow-up 1	27.8	59.8	0.0	9.8	0.0	2.6	266
	Follow-up 2	44.4	51.1	0.0	2.3	0.0	2.3	166
	Follow-up 3	51.1	41.4	0.0	6.0	0.0	1.5	266
	Primary	0.0	30.2	31.3	33.6	3.0	1.9	265
	Follow-up 1	31.3	60.0	0.0	4.5	0.0	4.2	265
	Follow-up 2	42.6	54.3	0.0	1.9	0.0	1.1	265
	Follow-up 3	50.9	45.7	0.0	1.9	0.4	1.1	265

Table 31. Non-Border Survey Results for School Bus Signs

Primary Question		What does this sign mean?						
Follow-up Question 1		When do you have to stop for a school bus?						
Follow-up Question 2		Why do you have to stop for a school bus?						
Follow-up Question 3		Does traffic in both directions have to stop?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	27.9	63.1	9.0	0.0	0.0	111
	Follow-up 1	0.0	96.4	N/A	3.6	0.0	0.0	111
	Follow-up 2	0.0	89.2	N/A	10.8	0.0	0.0	111
	Follow-up 3	0.0	95.5	N/A	1.8	1.8	0.0	110
	Primary	N/A	30.8	60.7	8.5	0.0	0.0	117
	Follow-up 1	0.0	99.1	N/A	0.0	0.0	0.9	117
	Follow-up 2	0.0	88.9	N/A	7.7	0.0	2.6	116
	Follow-up 3	0.0	95.7	N/A	3.4	0.0	0.0	116

Table 32. Border Survey Results for Fasten Safety Belts Signs

Primary Question		What does this sign mean?						
Follow-up Question		Why is this sign important?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	0.0	8.7	68.1	5.1	13.0	5.1	254
	Follow-up	19.7	72.8	0.0	4.3	0.0	3.1	254
	Primary	0.0	9.8	78.3	2.0	7.1	2.8	254
	Follow-up	14.2	80.7	0.0	3.5	0.0	1.6	254
	Primary	0.0	6.3	82.7	1.6	6.7	2.7	255
	Follow-up	12.2	82.0	0.0	1.2	0.0	4.7	255
	Primary	0.0	8.6	80.1	3.9	5.5	2.0	256
	Follow-up	14.5	82.0	0.0	0.4	0.0	3.1	256

Table 33. Non-Border Survey Results for Fasten Safety Belts Signs

Primary Question		What does this sign mean?						
Follow-up Question		Why is this sign important?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	2.2	97.4	0.4	0.0	0.0	228
	Follow-up	0.0	90.8	N/A	8.8	0	0.4	228

Table 34. Border Survey Results for Right Lane Ends Signs

Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	0.0	70.7	2.4	12.9	11.2	2.8	249
	Follow-up	22.9	58.2	0.0	16.5	0.0	2.4	249
	Primary	0.0	72.1	9.4	12.3	4.5	1.6	244
	Follow-up	15.6	64.3	0.0	16.0	0.0	4.1	244
	Primary	0.0	69.5	7.0	16.4	4.7	2.3	256
	Follow-up	17.2	60.5	0.0	18.0	0.0	4.3	256
	Primary	0.0	64.4	8.1	20.6	4.0	2.8	247
	Follow-up	20.2	56.3	0.0	20.2	0.0	3.2	247

Table 35. Non-Border Survey Results for Right Lane Ends Signs

Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	79.4	20.2	0.4	0.0	0.0	228
	Follow-up	0.0	97.4	N/A	1.8	0.0	0.9	228

Table 36. Border Survey Results for Weigh Station Signs

Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
WEIGH STATION NEXT RIGHT OPEN	Primary	0.0	1.3	18.4	47.4	27.6	5.3	76
	Follow-up	52.6	30.3	0.0	15.8	0.0	1.3	76
ESTACION DE PESAJE PROXIMA DERECHA ABIERTO	Primary	0.0	1.3	26.6	59.5	7.6	5.1	79
	Follow-up	27.8	29.1	0.0	32.9	0.0	10.1	79
ESTACION DE PESADO PROXIMA DERECHA ABIERTO	Primary	0.0	2.6	35.5	51.3	3.9	6.6	76
	Follow-up	17.1	42.1	0.0	31.6	0.0	9.2	76
BASCULA PROXIMA DERECHA ABIERTO	Primary	0.0	6.5	37.7	51.9	0.0	3.9	77
	Follow-up	11.7	63.6	0.0	16.9	0.0	7.8	77

Table 37. Non-Border Survey Results for Weigh Station Signs

This sign was not included in the non-border survey as that survey was conducted at a weigh station on an Interstate Highway.

Table 38. Border Survey Results for Weight Limit Signs

Primary Question		What does this sign mean?						
Follow-up Question 1		Why is this sign used?						
Follow-up Question 2		Does the limit refer to the total weight or the weight per axle?						
Follow-up Question 3		How much is a ton?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
WEIGHT LIMIT 10 TONS	Primary	0.0	37.0	35.8	18.5	3.7	3.7	81
	Follow-up 1	30.9	53.1	0.0	11.1	0.0	4.9	81
	Follow-up 2	25.9	50.6	0.0	19.8	1.2	2.5	81
	Follow-up 3	24.7	6.2	0.0	64.2	3.7	1.2	81
LIMITE DE PESO 10 TONS	Primary	0.0	41.8	50.6	6.3	0.0	1.3	79
	Follow-up 1	19.0	58.2	0.0	12.7	0.0	10.1	79
	Follow-up 2	5.1	58.2	0.0	31.6	2.5	2.5	79
	Follow-up 3	5.1	2.5	0.0	81.0	5.1	6.3	79
PESO LIMITADO 10 TONS	Primary	0.0	52.6	35.5	9.2	0.0	2.6	76
	Follow-up 1	22.4	55.3	0.0	13.2	0.0	9.2	76
	Follow-up 2	5.3	57.9	0.0	27.6	3.9	5.3	76
	Follow-up 3	5.3	5.3	0.0	77.6	5.3	6.6	76
PESO MAXIMO 10 TONS	Primary	0.0	62.3	27.3	3.9	2.6	3.9	77
	Follow-up 1	20.0	68.8	0.0	5.2	0.0	5.2	77
	Follow-up 2	6.5	64.9	0.0	18.2	3.9	6.5	77
	Follow-up 3	6.5	1.3	0.0	83.1	3.9	5.2	77

Table 39. Non-Border Survey Results for Weight Limit Signs

Primary Question		What does this sign mean?						
Follow-up Question 1		Why is this sign used?						
Follow-up Question 2		Does the limit refer to the total weight or the weight per axle?						
Follow-up Question 3		How much is a ton?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
WEIGHT LIMIT 10 TONS	Primary	N/A	28.6	67.1	4.3	0.0	0.0	210
	Follow-up 1	0.0	88.1	N/A	10.5	0.0	1.4	210
	Follow-up 2	0.0	91.9	N/A	6.2	1.9	0.0	210
	Follow-up 3	This question was not asked.						

Table 40. Border Survey Results for Load Zoned Bridge Signs

Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	0.0	3.8	21.8	34.6	34.6	5.1	78
	Follow-up	59.0	9.0	1.3	28.2	0.0	2.6	78
	Primary	0.0	2.6	38.5	37.2	17.9	3.8	78
	Follow-up	39.7	12.8	1.3	33.3	0.0	12.8	78
	Primary	0.0	1.3	89.5	9.2	0.0	0.0	76
	Follow-up	2.6	39.5	5.3	44.7	0.0	7.9	76
	Primary	0.0	48.1	49.4	1.3	0.0	1.3	77
	Follow-up	3.9	63.6	14.3	10.4	1.3	6.5	77

Table 41. Non-Border Survey Results for Load Zoned Bridge Signs

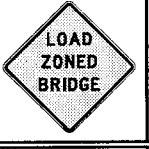
Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	38.7	50.9	7.5	1.9	0.9	106
	Follow-up	0.0	57.0	23.4	15.0	2.8	1.9	107
	Primary	N/A	39.4	50.0	9.6	0.0	1.0	104
	Follow-up	0.0	58.7	22.1	16.3	2.9	0.0	104

Table 42. Border Survey Results for Hazardous Cargo Signs

Primary Question		What does this sign mean?						
Follow-up Question		What does the symbol inside the circle mean?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	2.6	7.7	20.5	56.4	12.8	78
	Follow-up	89.7	0.0	N/A	3.8	2.6	3.8	78
	Primary	N/A	2.6	10.5	18.4	57.9	10.5	76
	Follow-up	89.5	0.0	N/A	2.6	7.9	0.0	76
	Primary	N/A	0.0	2.6	15.6	67.5	14.3	77
	Follow-up	94.8	0.0	N/A	1.3	3.9	0.0	77
	Primary	N/A	2.6	10.3	19.2	53.8	14.1	78
	Follow-up	87.2	1.3	N/A	3.8	6.4	1.3	78

All signs have either a green circle with no slash or a red circle with slash. The four color diamond sign has red on top, blue on left, yellow on right, and white on bottom.

Table 43. Non-Border Survey Results for Hazardous Cargo Signs

Primary Question		What does this sign mean?						
Follow-up Question		What does the symbol inside the circle mean?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	20.8	62.3	9.4	7.5	0.0	53
	Follow-up	90.6	7.5	N/A	0.0	1.9	0.0	53
	Primary	N/A	11.3	37.7	18.9	26.4	5.7	53
	Follow-up	98.0	2.0	N/A	0.0	0.0	0.0	49
	Primary	N/A	9.8	72.5	5.9	11.8	0.0	51
	Follow-up	95.8	2.1	N/A	0.0	0.0	2.1	48
	Primary	N/A	38.0	48.0	0.0	10.0	4.0	50
	Follow-up	88.7	3.8	N/A	7.5	0.0	0.0	53

All signs have either a green circle with no slash or a red circle with slash. The four color diamond sign has red on top, blue on left, yellow on right, and white on bottom.

Table 44. Border Survey Results for Sign Shape

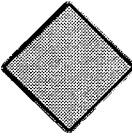
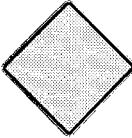
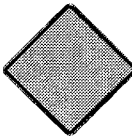
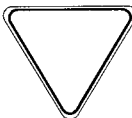
Primary Question		What does a sign with this shape mean?				
Follow-up Question		No question asked.				
Device	Questions	Correct	Incorrect	Not Sure	Unknown	Sample Size
 Orange	Primary	8.9	62.3	23.3	5.5	292
 Yellow	Primary	32.0	36.7	24.1	7.1	294
 White	Primary	52.0	30.3	12.6	5.1	294

Table 45. Non-Border Survey Results for Sign Shape

Primary Question		What does a sign with this shape mean?				
Follow-up Question		No question asked.				
Device	Questions	Correct	Incorrect	Not Sure	Unknown	Sample Size
 Orange	Primary	19.8	66.8	12.0	1.4	217
 White	Primary	84.6	11.8	2.7	0.9	221

APPENDIX B

KEY WORD RESPONSE CONCEPTS

STOP FOR SCHOOL BUS SIGNS

The key word responses to the primary comprehension question “What does this sign mean?” are summarized in Table 46. As outlined in the study design, a correct response was one which included the following key words: “stop,” “school bus,” and “loading or unloading” or “stop,” “school bus,” and “lights flashing.” The concept “school bus stop” was not considered correct as drivers who responded this way thought that the sign marked one particular spot at which school buses stopped; they thought the sign to be the school equivalent to a transit bus stop sign. As expected, the words “stop” and “school bus” were commonly heard as a response to the standard sign and each of the alternatives with at least 70 percent of the respondents mentioning the word “stop” and approximately 60 percent of the respondents mentioning the term “school bus.” The word “stop” was mentioned most often in response to the standard sign (78.4 percent of respondents), and the term “school bus” was heard most often in response to the STOP FOR SCHOOL BUS WHEN RED LIGHTS FLASHING sign (67.3 percent of respondents). The fact that the predominantly Spanish-speaking border drivers are familiar with these English words suggests a familiarity with English-language school bus signing. Logically, the “loading or unloading” and “children” concepts were the most frequent responses to the standard sign, STOP FOR SCHOOL BUS LOADING OR UNLOADING; “loading or unloading” was mentioned by 29.7 percent of respondents, and “children” was mentioned by 22.3 percent. Responses to the other three alternatives, all of which make reference to stopping when the red lights are flashing, reflect this difference in sign legend with higher percentages (26.7 percent, 19.9 percent, and 25.7 percent, respectively) of people mentioning the “lights flashing” concept.

Common incorrect responses included “school zone” and “school bus stop.” These key words were most often mentioned in response to the English-legend signs. With respect to the “school zone” response, many people who mentioned this concept did understand that they must stop when a school bus stops to load or unload children, but they thought they need only stop in school zones. This misconception rendered their response incorrect. Several people responded that the sign was indicating a curve in the road ahead. Though this response was unexpected, a possible explanation would be that the survey participant perhaps did not understand the language of the sign. Therefore, participants may have used visual cues from the in-context picture, which displayed a slight curve in the roadway, to draw a conclusion that the sign was related to the roadway geometry.

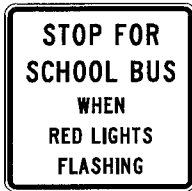
Table 46. Border Survey Key Word Responses to Stop for School Bus Signs

Key Word or Concept		STOP FOR SCHOOL BUS LOADING OR UNLOADING		STOP FOR SCHOOL BUS WHEN RED LIGHTS FLASHING		ALTO CUANDO AUTOBUS ESCOLAR PONE SENALES ROJAS DESTELLANDO		ALTO CUANDO AUTOBUS ESCOLAR PONE LUCES ROJAS INTERMITENTES	
		n=269		n=266		n=266		n=265	
		Total	% ¹	Total	%	Total	%	Total	%
Did Not Understand		3	1.1	5	1.9	6	2.3	7	2.6
Common Responses	Verbatim	15	5.6	16	6.0	15	5.6	10	3.8
	Stop	211	78.4	195	73.3	191	71.8	205	77.4
	School Bus	175	65.1	179	67.3	157	59.0	169	63.8
	Loading/Unloading	80	29.7	29	10.9	29	10.9	31	11.7
	Lights Flashing	11	4.1	71	26.7	53	19.9	68	25.7
	Children	60	22.3	41	15.4	36	13.5	41	15.5
	People	11	4.1	1	0.4	3	1.1	2	0.8
	School Zone	37	13.8	37	13.9	23	8.6	16	6.0
	School Bus Stop	8	3.0	9	3.4	2	0.8	1	0.4
	Caution, Go Slow	13	4.8	8	3.0	14	5.3	9	3.4
	Curve Ahead	2	0.7	4	1.5	2	0.8	3	1.1
	Other Incorrect	7	2.6	5	1.9	8	3.0	13	4.9
Not Sure		3	1.1	7	2.6	12	4.5	8	3.0
Indeterminate		1	0.4	2	0.8	5	1.9	5	1.9

¹ The sum of the percentages is greater than 100% as the responses are not mutually exclusive.

Both the standard sign (R19-1), with the text STOP FOR SCHOOL BUS LOADING OR UNLOADING, and the alternative sign, which replaced “LOADING OR UNLOADING” with “WHEN RED LIGHTS FLASHING,” had high comprehension levels. The results for these two signs are listed in Table 47. When asked about the meaning of the sign, a high percentage of the respondents read the sign legend verbatim. The standard sign had a slightly higher percentage of people respond with “stop” and “school bus.” As expected more respondents mentioned “load/unload” when shown the R19-1, while more respondents mentioned “lights flashing” when shown the alternative sign. The question in Set C, which asked if traffic in both directions was required to stop, provided a high percentage of correct responses for both signs. Worth noting was the response to a follow-up question which asked when drivers are required to stop for a school bus. As anticipated, a high percentage of drivers that were shown the alternative sign

Table 47. Non-Border Survey Key Word Responses to Stop for School Bus Signs

Key Word or Concept					
		n=111		n=117	
		Total	% ¹	Total	%
Did Not Understand		0	0.0	0	0.0
Common Responses	Verbatim	21	18.9	28	23.9
	Stop	84	75.7	84	71.8
	School Bus	81	73.0	80	68.4
	Loading/Unloading	33	29.7	6	5.1
	Lights Flashing	6	5.4	40	34.2
	Children	8	7.2	7	6.0
	People	3	2.7	0	0.0
	School Zone	N/R	N/R	N/R	N/R
	School Bus Stop	N/R	N/R	N/R	N/R
	Caution, Go Slow	N/R	N/R	N/R	N/R
	Curve Ahead	N/R	N/R	N/R	N/R
	Other Incorrect	0	0.0	0	0.0
Not Sure		0	0.0	0	0.0
Indeterminate		0	0.0	0	0.0

¹ The sum of the percentages is greater than 100% as the responses are not mutually exclusive.

N/R - Not recorded.

responded with “lights flashing.” However, a similarly high percentage of people that were shown the standard sign responded with not only “lights flashing,” but also “when it stops” and “loading/unloading.”

FASTEN SAFETY BELT SIGNS

The key word responses for the FASTEN SAFETY BELTS - STATE LAW sign and its alternatives can be found in Table 48. For these signs, a correct response was one which included the key words, “safety belt” or “seat belt,” “fasten belt” or “must wear belt,” and “state law.” In examining how survey participants responded, it is worthwhile to note that for the standard sign and all alternatives, the number of drivers who responded “seat belt” and “must wear belt” were roughly equal for each sign tested. For example, for the FASTEN SAFETY BELTS - STATE LAW sign, the percentage of drivers who responded “seat belt” was 16.9 percent, and the number who responded “must wear belt” was 14.6 percent. The same trend can be noted between the concepts “safety belt” and “fasten belt”; for the ABROCHESE EL CINTURON DE SEGURIDAD - LEY ESTATAL sign, these percentages were 57.9 percent and 56.3 percent, respectively.

If one refers to the passenger car driver survey demographics, these trends correspond to the breakdown between English and Spanish as primary language; English was the primary language of 16.0 percent of the survey participants, and 81.0 percent said their primary language was Spanish. Further review of the data by the researchers confirmed that the response combination “seat belt” and “must wear belt” was most often offered by English-speaking survey participants, and “safety belt” and “fasten belt” was most often given by Spanish-speaking drivers. These trends are logical as in the United States, passenger restraints are most commonly referred to as seat belts, and seat belt usage is mandated by law. In Mexico, there is no history of mandatory seat belt usage; many citizens do not wear them. One of the follow-up questions for seat/safety belt signs was “Why is this sign important?” Rather than responding that the law requires seat belt usage as expected, many of the Spanish-speaking drivers focused on a safety aspect, responding that the sign was important because safety belts provided additional protection in case of an automobile accident.

One notable incorrect response was that the sign was warning of rough or deteriorated pavement ahead and cautioning drivers to proceed slowly. Again, the inappropriate response can be explained by the in-context picture shown in the survey. The picture showed a rural Texas road, bleached by the sun and patched with dark crack sealant. A respondent looking to the picture for a visual cue could easily interpret the sign to mean “rough road ahead.”

Table 48. Key Word Responses to Fasten Safety Belts Signs

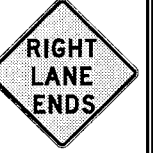
Key Word or Concept		Border								Non-Border	
		FASTEN SAFETY BELTS STATE LAW		ASEGURESE EL CINTURON DE SEGURIDAD LEY ESTATAL		ABROCHESE EL CINTURON DE SEGURIDAD LEY ESTATAL		PONGASE EL CINTURON DE SEGURIDAD LEY ESTATAL		FASTEN SAFETY BELTS STATE LAW	
		n=254		n=254		n=255		n=256		n=228	
		Total	%	Total	%	Total	%	Total	%	Total	%
Did Not Understand		19	7.5	3	1.2	9	3.5	5	2.0	0	0.0
Common Responses	Verbatim	10	3.9	5	2.0	7	2.7	5	2.0	10	4.4
	Seat Belt	43	16.9	45	17.7	43	16.9	46	18.0	127	55.7
	Safety Belt	115	45.3	147	57.9	142	55.7	153	59.8	91	39.9
	State Law	34	13.4	40	15.7	26	10.2	31	12.1	50	21.9
	Fasten Belt	111	43.7	143	56.3	158	62.0	134	52.3	N/R	N/R
	Must Wear Belt	37	14.6	41	16.1	37	14.5	35	13.7	38	16.7
	Bad Pavement	6	2.4	1	0.4	2	0.8	3	1.2	N/R	N/R
	Other Incorrect	5	2.0	4	1.6	2	0.8	7	2.7	1	0.4
Not Sure		33	13.0	18	7.1	17	6.7	14	5.5	0	0.0
Indeterminate		13	5.1	7	2.8	7	2.7	5	2.0	0	0.0

N/R - Not recorded.

RIGHT LANE ENDS SIGNS

The key words and concepts associated with the RIGHT LANE ENDS standard sign and its alternatives are summarized in Table 49. The correct response concept for this sign included the key words, "right lane ends," "lane ends," "move left," or "move to other lane." The percentage of drivers responding "right lane is closing" to the CARRIL DERECHO CERRADO sign (54.7 percent) simply reflects the literal translation of this sign, "right lane closed." Those participants who did not fully comprehend the sign tended to focus on the word "right" or "derecho" in the legends. They understood that something was happening in or to the right lane, but they were not exactly sure of what. Consequently, the incorrect responses could be grouped into several categories: "right lane will exit," "go to or stay in the right lane," and "left lane for passing, right lane for slower drivers." The only other common incorrect response was "road ends." This response was often given when a driver was shown the FIN DE CARRIL DERECHO sign (4.9 percent of respondents). It would seem that the driver focused on the word "fin," which translates to "end" in English.

Table 49. Key Word Responses to Right Lane Ends Sign and Alternative Signs

Key Word or Concept											
		n=249		n=244		n=256		n=247		n=228	
		Total	%	Total	%	Total	%	Total	%	Total	%
Did Not Understand		18	7.2	1	0.4	8	3.1	5	2.0	0	0.0
Common Responses	Verbatim	8	3.2	28	11.5	23	9.0	32	13.0	74	32.5
	Right Lane is Ending	156	62.7	132	54.1	15	5.9	106	42.9	124	54.4
	Right Lane is Closing	14	5.6	0	0.0	140	54.7	0	0.0	N/R	N/R
	Move Left	8	3.2	17	7.0	17	6.6	8	3.2	104	45.6
	Lane Ending	13	5.2	42	17.2	8	3.1	51	20.6	15	6.6
	Lane Closing	0	0.0	0	0.0	14	5.5	0	0.0	N/R	N/R
	Move to Other Lane	5	2.0	6	2.5	9	3.5	7	2.8	18	7.9
	Right Lane is an Exit	4	1.6	0	0.0	3	1.2	1	0.4	N/R	N/R
	Go/Stay in Right Lane	4	1.6	4	1.6	9	3.5	3	1.2	N/R	N/R
	Left Lane for Passing	3	1.2	2	0.8	0	0.0	2	0.8	N/R	N/R
	Road Ends	2	0.8	6	2.5	5	2.0	12	4.9	N/R	N/R
	Other Incorrect	19	7.6	18	7.4	19	7.4	29	11.7	1	0.4
Not Sure		28	11.2	11	4.5	13	5.1	10	4.0	0	0.0
Indeterminate		7	2.8	4	1.6	6	2.3	7	2.8	0	0.0

N/R - Not recorded.

WEIGH STATION SIGNS

As with the passenger car driver survey, it was useful to analyze the results of the truck driver survey with respect to the key words and concepts mentioned for each standard sign and alternative. Table 50 lists the key words and concepts given in response to weigh station sign comprehension questions. A correct response for this sign included the key words “weigh station,” “ahead on right,” “open,” and “must stop and get weighed.” As the table shows, the BASCULA - PROXIMA DERECHA - ABIERTO legend was far more effective than the other legends in communicating the “weigh station” concept; 89.6 percent of the respondents mentioned the term “weigh station” in their response as opposed to 35.5 percent, 51.9 percent, and 65.8 percent, respectively, for the other signs. Consequently, it is a logical corollary that the same legend had the highest percentage of respondents communicating the “must stop and get weighed” concept (28.6 percent).

With respect to the incorrect responses, several people interpreted the white-on-green sign coloring to indicate a highway guide sign. Others comprehended that there was some sort of station ahead on the right which was open, but they did not know what type of station it was. One common misconception in this regard was that it was some type of passenger station or highway rest stop.

Table 50. Border Key Word Responses to Weigh Station Signs

Key Word or Concept		WEIGH STATION NEXT RIGHT OPEN		ESTACION DE PESAJE PROXIMA DERECHA ABIERTO		ESTACION DE PESADO PROXIMA DERECHA ABIERTO		BASCULA PROXIMA DERECHA ABIERTO	
		n=76		n=79		n=76		n=77	
		Total	%	Total	%	Total	%	Total	%
Did Not Understand		9	11.8	2	2.5	0	0.0	0	0.0
Common Responses	Verbatim	1	1.3	13	16.5	11	14.5	9	11.7
	Weigh Station	27	35.5	41	51.9	50	65.8	69	89.6
	Ahead on Right	24	31.6	18	22.8	23	30.3	44	57.1
	Open	22	28.9	9	11.4	13	17.1	13	16.9
	Must Stop/Get Weighed	6	7.9	10	12.7	13	17.1	22	28.6
	Guide Sign	3	3.9	3	3.8	3	3.9	0	0.0
	Some Sort of Station	9	11.8	6	7.6	4	5.3	0	0.0
	Other Incorrect	4	5.3	10	12.7	0	0.0	1	1.3
Not Sure		22	28.9	6	7.6	3	3.9	0	0.0
Indeterminate		4	5.3	4	5.1	5	6.6	3	3.9

Note: This sign was not included in the non-border survey.

WEIGHT LIMIT SIGNS

Table 51 summarizes the responses to the primary question, “What does this sign mean?” for the standard weight limit sign and the three Spanish-legend alternatives. For a response to be considered correct, the following key words must have been mentioned: “weight limit” and “10 tons.” As with the WEIGH STATION - NEXT RIGHT - OPEN sign, border drivers did not have a high comprehension of the word “weight,” and only 55.6 percent of the participants who were shown this sign mentioned the “weight limit” concept. For the standard weigh station sign, truck drivers who did not understand the word “weigh,” focused their responses on the “station” aspect of the sign. For the WEIGHT LIMIT - 10 TONS sign, the non-comprehending drivers focused on the word “limit.” Many responded with this key word (23.5 percent) without specifying what type of limit. The presence of the number “10” and the black-on-white coloring of the sign led

some survey participants to conclude that the sign was a speed limit sign. This interpretation was seen only with the English-legend sign.

Table 51. Key Word Responses to Weight Limit Signs

Key Word or Concept		Border								Non-Border	
		WEIGHT LIMIT 10 TONS		LIMITE DE PESO 10 TONS		PESO LIMITADO 10 TONS		PESO MAXIMO 10 TONS		WEIGHT LIMIT 10 TONS	
		n=81		n=79		n=76		n=77		n=210	
		Total	%	Total	%	Total	%	Total	%	Total	%
Did Not Understand		2	2.5	1	1.3	0	0.0	0	0.0	0	0.0
Common Responses	Verbatim	2	2.5	9	11.4	9	11.8	11	14.3	54	25.7
	Weight Limit	45	55.6	61	77.2	62	81.6	59	76.6	110	52.4
	Road Limit	0	0.0	1	1.3	3	3.9	3	3.9	21	10.0
	Bridge Limit	0	0.0	1	1.3	1	1.3	1	1.3	32	15.2
	Limit	19	23.5	6	7.6	3	3.9	2	2.6	25	11.9
	10 Tons	43	53.1	36	45.6	41	53.9	51	66.2	106	50.5
	Speed Limit	11	13.6	4	5.1	4	5.3	2	2.6	N/R	N/R
	Other Incorrect	1	1.2	0	0.0	2	2.6	0	0.0	5	2.4
Not Sure		4	4.9	0	0.0	0	0.0	2	2.6	0	0.0
Indeterminate		3	3.7	1	1.3	2	2.6	3	3.9	0	0.0

N/R - Not recorded.

LOAD ZONED BRIDGE

The key word responses for the final sign in the truck driver survey can be found in Table 52. A correct response for this sign included the key words “weight limit” and “bridge.” The Spanish-legend alternative PUENTE DE TAMANO LIMITADO showed higher percentages of “height limit” (19.7 percent) and “width limit” (43.4 percent) as the word “tamaño” refers to the dimensions of a truck and not simply the weight. Both the PUENTE DE TAMANO LIMITADO and PUENTE DE PESO LIMITADO Spanish legends had higher-than-average values for the “verbatim” response category, 31.6 percent and 39.5 percent, respectively. This may be due in part to the fact that each of these legends is quite self-explanatory, “bridge of limited size” and “bridge of limited weight,” respectively.

With regard to the incorrect responses, Spanish- (and some English-) speaking drivers were confused by the LOAD ZONED BRIDGE legend, and many thought it signified some sort of special or restricted zoning. Similarly, with the BRIDGE LIMIT sign, some truck drivers focused on the word “limit,” and several thought it was a speed limit sign.

Table 52. Border Key Word Responses for Load Zoned Bridge Signs

Key Word or Concept									
		n=78		n=78		n=76		n=77	
		Total	%	Total	%	Total	%	Total	%
Did Not Understand		12	15.4	1	1.3	0	0.0	0	0.0
Common Responses	Verbatim	6	7.7	2	2.6	24	31.6	30	39.5
	Weight Limit	3	3.8	3	3.8	1	1.3	46	60.5
	Height Limit	0	0.0	2	2.6	15	19.7	2	2.6
	Width Limit	4	5.1	2	2.6	33	43.4	4	5.3
	Bridge	21	26.9	30	38.5	55	72.4	49	64.5
	Limit	2	2.6	36	46.2	10	13.2	5	6.6
	Speed Limit/Zone	2	2.6	8	10.3	0	0.0	0	0.0
	Restricted Zone	10	12.8	0	0.0	0	0.0	0	0.0
	Work Zone	3	3.8	0	0.0	0	0.0	0	0.0
	Other Incorrect	11	14.1	6	7.7	1	1.3	1	1.3
Not Sure		29	37.2	14	17.9	0	0.0	0	0.0
Indeterminate		4	5.1	3	3.8	0	0.0	1	1.3

Table 53. Non-Border Key Word Responses for Load Zoned Bridge Signs

Key Word or Concept					
		n=106		n=104	
		Total	%	Total	%
Did Not Understand		0	0.0	0	0.0
Common Responses	Verbatim	37	34.9	35	33.7
	Weight Limit	51	48.1	53	51.0
	Height Limit	2	1.9	8	7.7
	Width Limit	0	0.0	3	2.9
	Bridge	53	50.0	48	6.2
	Limit	N/R	N/R	N/R	N/R
	Speed Limit/Zone	N/R	N/R	N/R	N/R
	Restricted Zone	N/R	N/R	N/R	N/R
	Work Zone	N/R	N/R	N/R	N/R
	Other Incorrect	0	0.0	0	0.0
Not Sure		2	1.9	0	0.0
Indeterminate		1	0.9	1	1.0

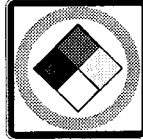
N/R - Not recorded.

HAZARDOUS CARGO SIGNS

Table 54. Border Key Word Responses for Hazardous Cargo Signs

Key Word or Concept									
		n=78		n=76		n=77		n=78	
		Total	%	Total	%	Total	%	Total	%
Did Not Understand		1	1.3	0	0.0	0	0.0	1	1.3
Common Responses	Hazardous Cargo	2	2.6	2	2.6	0	0.0	0	0.0
	Hazardous Materials/HazMat	2	2.6	5	6.6	1	1.3	3	3.8
	Hazardous Chemicals	1	1.3	2	2.6	0	0.0	0	0.0
	Hazardous	1	1.3	1	1.3	0	0.0	0	0.0
	Route	2	2.6	2	2.6	0	0.0	2	2.6
	Permitted/Prohibited	4	5.1	3	3.9	1	1.3	8	10.3
	Freeway Exit	10	128.0	9	11.8	9	11.7	7	9.0
	Other Incorrect	6	7.7	5	6.6	3	3.9	8	10.3
Not Sure		45	57.7	44	57.9	52	67.5	42	53.8
Indeterminate		10	12.8	8	10.5	11	14.3	11	14.1

Table 55. Non-Border Key Word Responses for Hazardous Cargo Signs

Key Word or Concept									
		n=53		n=53		n=51		n=50	
		Total	%	Total	%	Total	%	Total	%
Did Not Understand		0	0.0	0	0.0	0	0.0	0	0.0
Common Responses	Hazardous Cargo	23	43.4	2	3.8	1	2.0	1	2.0
	Hazardous Materials/HazMat	10	18.9	15	28.3	41	80.4	39	78.0
	Hazardous Chemicals	10	18.9	1	1.9	0	0.0	0	0.0
	Hazardous	2	3.8	8	15.1	0	0.0	1	2.0
	Route	10	18.9	3	5.7	3	5.9	4	8.0
	Permitted/Prohibited	3	5.7	3	5.7	2	3.9	19	38.0
	Freeway Exit	0	0.0	0	0.0	0	0.0	0	0.0
	Other Incorrect	0	0.0	1	1.9	0	0.0	0	0.0
Not Sure		4	7.5	15	28.3	6	11.8	5	10.0
Indeterminate		0	0.0	3	5.7	0	0.0	2	4.0