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16. Abstract

This report summarizes the findings of a three-year research project on comprehension of traffic control devices among drivers in Texas border areas. The research evaluated 116 different traffic control devices, which included 33 standard devices and numerous alternative designs for those standard devices. Evaluations consisted of driver surveys in which drivers were presented an image of a device and asked what it meant. Responses were recorded and later classified into categories that reflect understanding of the device. No changes are recommended for the large majority of the devices. Alternative Spanish-language or bilingual signs are recommended as supplements for six standard signs. Additional emphasis is recommended for three device categories. Three standard devices are recommended for modifications in design or use. Four devices are identified for future research efforts.

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TRAFFIC CONTROL DEVICES IN TEXAS BORDER AREAS: SUMMARY OF RESEARCH AND RECOMMENDATIONS

by

H. Gene Hawkins, Jr., Ph.D., P.E.
Associate Research Engineer
Texas Transportation Institute

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College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. The engineer in charge of the project was H. Gene Hawkins, Jr., P.E. #61509.

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Project Director

- Mr. Carlos Lopez, Traffic Operations Division, Texas Department of Transportation.

Project Advisory Panel

- Mr. Greg Brinkmeyer, Traffic Operations Division, Texas Department of Transportation;
- Ms. Terry Carson, formerly of the Laredo District, Texas Department of Transportation;
- Mr. Carlos Chavez, El Paso District, Texas Department of Transportation;
- Mr. Vic Garcia, formerly of the Office of International Relations, Texas Department of Transportation;
- Mr. Stephen Kern, Office of International Relations, Texas Department of Transportation;
- Mr. Jesus Leal, Pharr District, Texas Department of Transportation;
- Mr. Ted Ozuna, San Antonio District, Texas Department of Transportation;
- Mr. Anthony Palacios, Austin Division, Federal Highway Administration;
- Mr. Lewis Rhodes, Safer Rhodes, Inc.;
- Mr. Fitzgerald Sanchez, Laredo District, Texas Department of Transportation; and
- Ms. Jeanie Swanson, Traffic Operations Division, Texas Department of Transportation.

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IMPLEMENTATION RECOMMENDATIONS

During the course of this research project, the researchers evaluated 116 different traffic control devices, including both standard and alternative designs for many different signs. The results of the evaluations have been used to group the devices into five action categories as listed below. Within each category are listed the devices recommended for that action.

- **No Changes to Current Practice**
  - Stop sign.
  - Yield sign.
  - Speed Limit sign.
  - Do Not Enter sign.
  - One Way sign.
  - Curve with Advisory Speed Plate sign.
  - Two-Way Traffic sign.
  - Railroad Advance sign.
  - School Crossing sign.
  - Road Work Ahead sign.
  - Truck Speed Limit sign.
  - Hill sign.
  - Clearance sign.
  - Hazardous Cargo Route and Hazardous Cargo Prohibited signs.
  - Traffic signal indications.
  - Pavement markings.
- **Supplemental Use of Alternative Sign**
  - Stop for School Bus sign.
  - Fasten Safety Belts sign.
  - Right Lane Ends sign.
  - Weight Limit 10 Tons sign.
  - Weigh Station sign.
  - Load Zoned Bridge sign.
- **Increased Emphasis in Education**
  - Railroad Advance sign.
  - Sign shape and color.
  - All pavement markings.
- **Change in Design or Use**
  - Railroad Advance sign.
  - Right Lane Closed sign.
  - Protected Left on Green Arrow sign.
- **Additional Research**
  - Stop for School Bus When Red Lights Flashing sign.
  - Hazardous Cargo Route and Hazardous Cargo Prohibited signs.
  - Weight-related signs: regulatory, warning, and guide.

CHAPTER 1
BACKGROUND

The areas of Texas along the Mexican border have always possessed many unique characteristics that make them distinct from other areas of Texas. The Hispanic influence and the predominance of Spanish as the spoken language are the most significant factors that make these areas so different from the rest of the state. Not only is there a predominant Hispanic presence among Texas border area residents, 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 traffic control devices used in Mexico and Texas, 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 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 project, conducted by the Texas Transportation Institute (TTI), began in the fall of 1995. During the three-year duration of the project, researchers conducted numerous surveys to assess driver comprehension of a wide variety of traffic control devices. The bulk of these surveys were conducted in Texas border areas, but some of the third-year surveys were conducted in non-border areas to provide a basis of comparison for some of the results.

Table 1 presents a summary of the survey activities conducted during the course of the research project. The results of each year of the project are described in a separate research report as referenced in the table. This report summarizes the findings of the three years of data collection and presents the overall project recommendations.

The surveys were administered at locations where drivers congregated and had an opportunity to answer questions while waiting for a service. The border surveys were all conducted at border crossings between Texas and Mexico. The non-border truck survey was conducted at a weigh station and the non-border passenger car survey was conducted at a driver license station. The surveys were all conducted in a similar manner. Drivers were approached and asked to participate. Drivers could respond in English or Spanish, whichever was more comfortable for them. If they agreed, they were shown a series of flashcards containing images of various traffic control devices. Figure 1 illustrates a typical flashcard from the third-year evaluations. For the first- and second-year evaluations, only

Table 1. Summary of Survey Efforts

Year and Report[1]	Location[2]	Driver Sample	Approximate Sample Size[3]	Number of Standard Devices	Number of Alternative Devices
1st 1274-1 Ref. (1)	Border	Passenger cars with Mexican license plates	605	25	0
		Commercial vehicles	154	8	0
2nd 1274-2 Ref. (2)	Border	Passenger cars with Texas license plates	546	25	5
		Commercial vehicles	260	9	27 (3 sets of 9 signs)
3rd 1274-3 Ref. (3)	Border	Passenger cars	1,116	5	9 (3 sets of 3 signs)
		Trucks	315	5	12 (3 sets of 4 signs)
	Non-Border	Passenger cars	228	4	1
		Trucks	210	4	4

Notes: [1]See Reference chapter.
[2]Border area surveys were conducted at border crossings.
[3]The actual sample size for a given device may be less.

the device image was shown (bottom part of Figure 1). The in-context view was not provided. Once drivers were presented a device, they were asked to describe the meaning of the device. In most cases, they were also asked follow-up questions to help clarify their understanding of the device. All responses were recorded on audiotape. Responses were analyzed and classified into one of five categories: *correct*, *partially correct*, *incorrect*, *not sure*, or *indeterminate*. The concepts for classifying responses into these categories were carefully developed for each device. 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 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. The results were then presented in tables which were used to develop recommendations. Appendices A, B, C, and D contain these tables for the first-year, second-year, third-year border, and third-year non-border surveys.

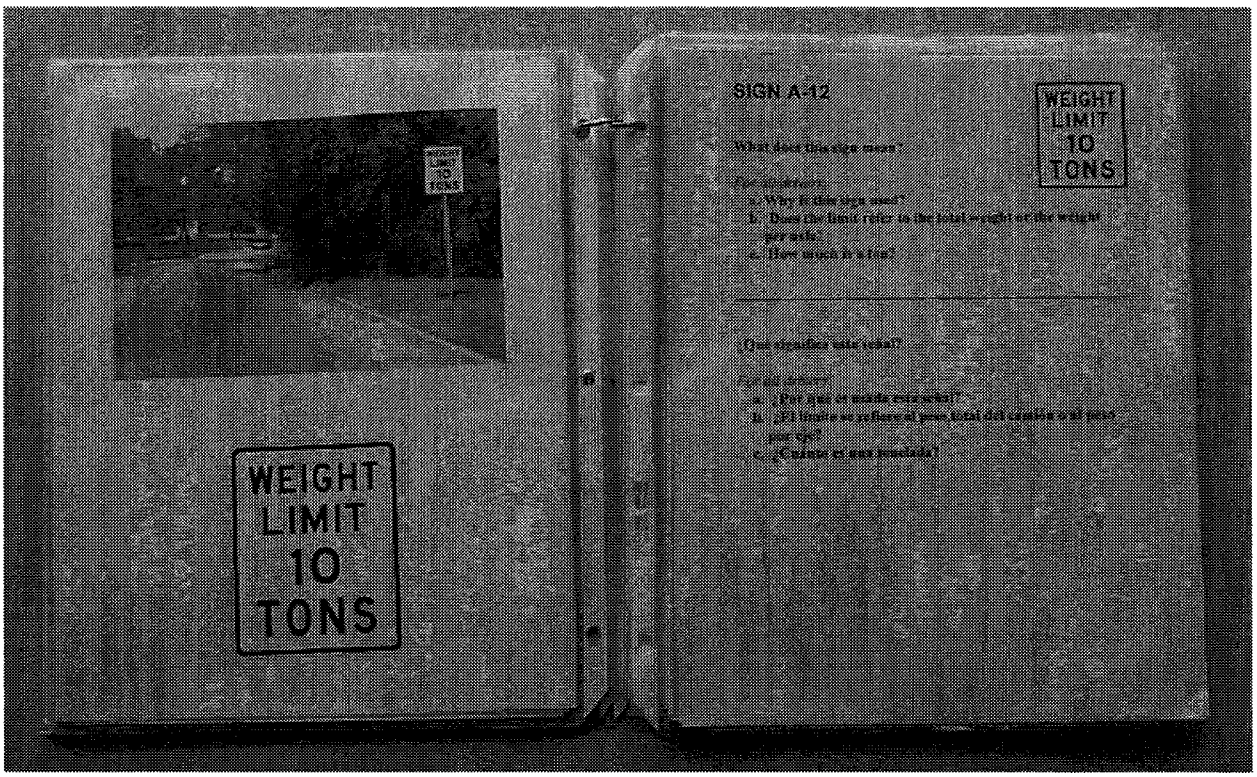


Figure 1. Typical Flashcard

In conducting the research, the researchers relied heavily upon the input and advice of numerous project advisors. The researchers met with these individuals in five formal meetings throughout the course of the research project. These five meetings were held in San Antonio, Edinburg, Laredo, El Paso, and Austin. The researchers also solicited advice from project advisors on an individual basis. The project advisors are listed in the Acknowledgments on page vi.

CHAPTER 2
FINDINGS AND RECOMMENDATIONS

During the course of this research project, the researchers evaluated 116 different traffic control devices. These devices included standard and alternative signs, standard pavement markings, and standard traffic signal indications with left turn signing. The findings from these evaluations are described in three different research reports (1, 2, 3). This chapter combines and summarizes the results for each device from all three years of the research effort. In addition to the summary, the section on each device includes the final research recommendations. The appendices in this report provide more detailed information regarding the questions, responses, response rates, and sample sizes for each device. Appendix A addresses the first-year devices, Appendix B addresses the second-year devices, Appendix C addresses the third-year border devices, and Appendix D addresses the third-year non-border devices.

The results from this research effort should be interpreted carefully. The driver samples for which the results are reported represent a small proportion of the overall driver population in the border and non-border areas. Experience has shown that there can be variability in comprehension levels from one sample to another.

Throughout this chapter, the terms "Mexican drivers" and "Texas drivers" are used to represent the first-year and second-year driver samples, respectively. Where the comprehension of two devices is compared and indicated to be statistically significant or not statistically significant, the analysis is based on a 90 percent confidence interval. Chapter 3 of the third-year report (3) contains a detailed description of the statistical analysis used to compare the significance of differences in response rates. In the summary tables in this chapter, the percentages represent the overall comprehension level, which is the correct plus the partially correct response. For some signs, there was no partially correct response, and the overall comprehension level is equal to the correct response rate. When this is the case, it is indicated in the notes for that table.

SIGNS

The vast majority of evaluations were focused upon traffic signs. These were grouped into three categories: regulatory, warning, and truck signs.

Regulatory Signs

The regulatory signs addressed in this research included the **Stop**, **Yield**, **Day/Night Speed Limit**, **Do Not Enter**, **One Way**, **Stop for School Bus**, and **Fasten Safety Belt**. For four of these standard signs, the researchers evaluated Spanish-legend alternatives. The following sections summarize the first-, second-, and third-year findings for each of these signs, along with the overall recommendations regarding the design and use of the sign.

Stop Sign

The **Stop** sign (R1-1) was included in the first- and second-year evaluations. Table 2 summarizes the findings associated with this sign. Among the first-year Mexican border drivers, 99 percent provided a correct response to this sign. Among the second-year Texas border drivers, 98 percent provided a correct response to this sign. There was no acceptable partially correct response for this sign, so the correct responses represent the overall comprehension levels. Based on these results, the researchers recommend that no changes be made to design or use of this sign.

Yield Sign

The **Yield** sign (R1-2) was included in the first- and second-year evaluations. Table 2 summarizes the findings associated with this sign. The Mexican equivalent to this sign (Ceda El Paso) was also included in the second-year survey. Among the first-year Mexican border drivers, 64 percent provided a correct response to this sign. Among the second-year Texas border drivers, 81 percent provided a correct response to this sign. The Spanish-legend alternative had a correct response rate of 85 percent. There is no statistically significant difference between the two signs in the second-year survey. There was no acceptable partially correct response for this sign, so the correct responses represent the overall comprehension levels.

Understanding of the **Yield** sign among all Texas drivers was addressed in a previous TTI research project (4). Almost 80 percent of the statewide driver sample selected a correct response for this sign from a list of multiple-choice responses. That report recommended no changes in the **Yield** sign.

The concept of a yield situation is a difficult one to verbalize in a survey. The researchers believe that this difficulty accounts for the lower comprehension levels found in the first-year survey. Furthermore, the only realistic alternative to the **Yield** sign would be a supplemental plaque with a legend of Ceda El Paso. In the second-year survey, this legend was found to not be statistically better than the standard **Yield** sign. Therefore, the researchers recommend no changes in the design or use of this sign.

Speed Limit Sign

The **Speed Limit** sign (R2-1) combined with a **Night Speed Limit** sign (R2-3) was included in the first- and second-year evaluations. Table 2 summarizes the findings associated with this sign. A Spanish-legend alternative to this sign (Velocidad Maxima/Noche) was also included in the second-year survey. The overall comprehension level of the speed limit message of this sign (correct plus partially correct) was 98 percent for the Mexican drivers (first year) and 99 percent for the Texas drivers (second year). The Spanish-legend alternative had a correct response rate of 96 percent. There is no statistically significant difference between the two signs in the second-year survey. The understanding of the difference between the day and night speed was also high, with 83 and 94 percent, respectively, for the Mexican and Texas drivers. For the Spanish-legend alternative, understanding of the day/night message was 97 percent.

Table 2. Summary of Findings and Recommendations, Selected Regulatory Signs

Device	Code	Overall Comprehension Level[1]		Recommendation
		1st Year	2nd Year	
	R1-1	98.7%[2]	97.6%[2]	Recommend no changes in design or use.
	R1-2	63.9%[2]	80.6%[2]	Recommend no changes in design or use.
	Alt. A	Not Included	85.2%[2]	Not recommended for implementation.
	R2-1 with R1-3	97.5% Day/night message 82.5%[2]	99.3% Day/night message 94.3%[2]	Recommend no changes in design or use.
	Alt. A	Not Included	98.5% Day/night message 96.9%[2]	Not recommended for implementation.
	R5-1	90.7%[2]	96.1%[2]	Recommend no changes in design or use.
	R6-1	83.3%[2]	91.8%[2]	Recommend no changes in design or use.

Note: These signs were addressed in the first- and second-year surveys only.
[1]Correct plus partially correct response rate.
[2]There was no partially correct response for this sign.

Based on these results, the researchers recommend that no changes be made to design or use of the **Day/Night Speed Limit** sign. The truck speed limit sign was also addressed in this project, and recommendations regarding that sign are provided on page 19.

Do Not Enter Sign

The **Do Not Enter** sign (R5-1) was included in the first- and second-year evaluations. Table 2 summarizes the findings associated with this sign. Among the first-year Mexican border drivers, 91 percent provided a correct response to this sign. Among the second-year Texas border drivers, 96 percent provided a correct response to this sign. There was no acceptable partially correct response for this sign, so the correct responses represent the overall comprehension levels. Based on these results, the researchers recommend that no changes be made to design or use of this sign.

One Way Sign

The **One Way** sign (R6-1) was included in the first- and second-year evaluations. Table 2 summarizes the findings associated with this sign. Among the first-year Mexican border drivers, 83 percent provided a correct response to this sign. Among the second-year Texas border drivers, 92 percent provided a correct response to this sign. There was no acceptable partially correct response for this sign, so the correct responses represent the overall comprehension levels. Based on these results, the researchers recommend that no changes be made to design or use of this sign.

Stop for School Bus Sign

The **Stop for School Bus** sign (R19-1) was addressed in all three years of the research project. Table 3 summarizes the findings associated with this sign. Alternatives to this sign included an English-language sign and three different Spanish-legend signs. Among the first-year Mexican border drivers, the overall comprehension level for the standard sign was 82 percent. Among the second-year Texas border drivers, the overall comprehension level was 90 percent. In the third year of the survey, the overall comprehension level was 65, 88, and 87 percent, for Spanish-speaking border drivers, English-speaking border drivers, and the non-border drivers, respectively.

The alternative designs of this sign had overall comprehension levels that ranged from 52 to 95 percent. The two signs with English-based legends had comprehension levels of approximately 90 percent among the samples that included primarily English-speaking drivers (second-year, third-year border English, and third-year non-border). One of the Spanish-legend signs (**Alto Para Autobus Escolar Subiendo O Bajando Pasaje**) had an overall comprehension level of 95 percent in the second-year survey. The other two Spanish-legend signs had overall comprehension levels of 50 to 65 percent among both the Spanish- and English-speaking driver samples in the third-year border survey.

Based on the results of the evaluations, the standard sign should continue to be used for all applications. Where engineering judgement indicates safety or compliance concerns in a border district, the **Alto Para Autobus Escolar Subiendo O Bajando Pasaje** sign may be installed to supplement the standard sign. Factors to be considered in making the judgement include the proportion of Spanish-speaking citizens in the immediate area of the sign, the extent to which the highway is used as a school bus route, the number of school bus stops on the highway, and documented compliance problems on the given highway. When used, the supplemental Spanish-legend sign should be installed downstream of the standard sign. The placement distance between the two signs should be based on the warning sign placement distances in Table 2C-1 of the Texas

MUTCD (5). For a 70 mph speed, this distance is 925 feet. The sign with the legend "**Stop for School Bus When Red Lights Flashing**" had a comprehension level that was higher than that for the standard sign. However, since the improvement was not statistically significant, the standard sign should continue to be used. However, any future research on sign comprehension should include the **Stop for School Bus When Red Lights Flashing** sign.

Table 3. Summary of Findings and Recommendations, Stop for School Bus Signs

Device	Code	Overall Comprehension Level[1]					Recommendation
		1st Year	2nd Year	3rd Year			
				Border		Non-Border	
	R19-1	82.1%	90.4%	65.0% (Spanish)	88.2% (English)	87.3%	Recommend no changes in design or use. Alternative B may be used to supplement this sign.
	Alt. A	Not Included	Not Included	66.2% (Spanish)	91.1% (English)	88.9%	This sign should be evaluated in future research.
	Alt. B	Not Included	94.6%	Not Included	Not Included	Not Included	This sign may be used to supplement the standard sign.
	Alt. C	Not Included	Not Included	61.7% (Spanish)	59.6% (English)	Not Included	Not recommended for implementation.
	Alt. D	Not Included	Not Included	65.1% (Spanish)	52.1% (English)	Not Included	Not recommended for implementation.

Notes: [1]Correct plus partially correct response rates.

Fasten Safety Belt Sign

The **Fasten Safety Belt** sign (R19-8) was addressed in all three years of the research project. Table 4 summarizes the findings associated with this sign. Alternatives to this sign included five different Spanish-legend signs. Among the first-year Mexican border drivers, the overall comprehension level for the standard sign was 56 percent. Among the second-year Texas border drivers, the overall comprehension level was 90 percent. In the third year of the survey, the overall comprehension level was 77, 96, and 100 percent, for Spanish-speaking border drivers, English-speaking border drivers, and the non-border drivers, respectively.

Table 4. Summary of Findings and Recommendations, Fasten Safety Belt Signs

Device	Code	Overall Comprehension Level[1]					Recommendation
		1st Year	2nd Year	3rd Year			
				Border		Non-Border	
	R19-8	56.4%	90.3%	76.8% (Spanish)	96.1% (English)	99.5%	Recommend no changes in design or use. Alternative C may be used to supplement this sign.
	Alt. A	Not Included	80.2%	Not Included	Not Included	Not Included	Not recommended for implementation.
	Alt. B	Not Included	88.3%	Not Included	Not Included	Not Included	Not recommended for implementation.
	Alt. C	Not Included	Not Included	95.5% (Spanish)	71.4% (English)	Not Included	This sign may be used to supplement the standard sign.
	Alt. D	Not Included	Not Included	95.5% (Spanish)	75.5% (English)	Not Included	Not recommended for implementation.
	Alt. E	Not Included	Not Included	96.1% (Spanish)	63.6% (English)	Not Included	Not recommended for implementation.

Notes: [1]Correct plus partially correct response rates.

The alternative designs of this sign had overall comprehension levels that ranged from 64 to 96 percent. The most effective of the five signs were the three that were evaluated in the third-year

survey. All three had overall comprehension levels of 96 percent, while the two second-year survey signs had overall comprehension levels of less than 90 percent. There is not a statistically significant difference in the overall comprehension level of the three signs evaluated in the third-year survey. Table 5 compares the third-year correct and partially correct response rates for all three of these signs. The results are divided into the Spanish-speaking sample, the English/bilingual sample, and the entire border sample. There are no statistically significant differences in the performance of these three signs. Consequently, it is not possible to establish that one alternative is any better than any others on the basis of the overall comprehension level. A more visible difference between the alternatives can be identified by looking at the correct comprehension rate among the Spanish-speaking sample. In doing so, the **Asegurese El Cinturon De Seguridad – Ley Estatal** sign emerges as the best understood by a small amount. Although the difference is not statistically significant, it provides a better indication of the relative performance than a comparison of the overall comprehension levels.

Table 5. Comparison of Third-Year Results for Fasten Safety Belt Sign Alternatives

Sign	3rd Year Border Spanish		3rd Year Border English		3rd Year Border All	
	Correct	Partially Correct	Correct	Partially Correct	Correct	Partially Correct
	11.1%	84.3%	6.1%	65.3%	10.1%	80.6%
	Overall = 95.5% n=198		Overall = 71.4% n=49		Overall = 90.7% n=247	
	7.5%	87.9%	2.0%	73.5%	6.5%	85.1%
	Overall = 95.5% n=199		Overall = 75.5% n=49		Overall = 91.5% n=248	
	8.7%	87.4%	9.1%	54.5%	8.8%	81.7%
	Overall = 96.1% n=207		Overall = 63.6% n=44		Overall = 90.4% n=251	

Response rates and sample sizes do not include indeterminate (unknown) responses.

Based on the results of the evaluations, the standard sign should continue to be used for all applications. Where engineering judgement indicates safety or compliance concerns in a border district, the **Asegurese El Cinturon De Seguridad – Ley Estatal** sign may be installed to supplement the standard sign. Factors to consider in deciding whether to use this sign include: identified compliance problems and higher rates of fatalities with unbelted occupants on the given highway. When used, the supplemental Spanish-legend sign may be installed adjacent to or downstream of the standard sign. The adjacent installation is appropriate where vehicle speeds are low (such as rest or picnic areas). If the signs are installed on the same post, the standard sign should appear at the top of a vertical arrangement or on the left of a horizontal arrangement. On the highway proper, the supplemental sign should be installed downstream of the standard sign. The placement distance between the two signs should be based on the warning sign placement distances in Table 2C-1 of the Texas MUTCD (5). For a 70 mph speed, this distance is 925 feet. Future

evaluations of sign comprehension in border and/or non-border areas should evaluate the three third-year alterative signs to determine if one of the alternatives can be identified as more effective than the other signs.

Warning Signs

The warning signs addressed in this research included the **Curve** with **Advisory Speed Plate**, **Two-Way Traffic**, **Railroad Advance**, **School Crossing**, **Road Work Ahead**, **Right Lane Ends**, and the difference between yellow and orange warning signs. Four of the six signs were symbol signs. The researchers evaluated Spanish-legend alternatives for one of the two word message signs. The following sections summarize the first-, second-, and third-year findings for each of these signs, along with the overall recommendations regarding the design and use of the sign.

Curve Sign with Advisory Speed Plate

The **Curve** sign (W1-2) with an **Advisory Speed Plate** (W13-1) was included in the first- and second-year evaluations only. Table 6 summarizes the findings associated with this sign. The overall comprehension level for the first-year survey was 96 percent. It was 92 percent for the second-year survey. Appendices A and B provide additional information on the responses to the follow-up questions. Although the overall comprehension levels for the two survey samples on this sign (Mexican and Texas drivers) are statistically significantly different, the comprehension was actually higher among the Mexican driver sample. Furthermore, comprehension levels among both driver samples was over 90 percent. Based on these results, the researchers recommend no changes in the design or use of this sign.

Two-Way Traffic Sign

The **Two-Way Traffic** sign (W6-3) was included in the first- and second-year evaluations only. Table 6 summarizes the findings associated with this sign. The overall comprehension level for the first-year survey was 94 percent. It was 87 percent for the second-year survey. Although the overall comprehension levels for the two survey samples on this sign (Mexican and Texas drivers) are statistically significantly different, the comprehension was actually higher among the Mexican driver sample. Furthermore, comprehension levels among both driver samples was over 85 percent. Based on these results, the researchers recommend no changes in the design or use of this sign.

Railroad Advance Sign

The **Railroad Advance** sign (W10-1) was included in the first- and second-year evaluations only. Table 6 summarizes the findings associated with this sign. The overall comprehension level for the first-year survey was 80 percent. It was 94 percent for the second-year survey. The overall comprehension levels for the two survey samples on this sign (Mexican and Texas drivers) are statistically significantly different. Part of the difference in the comprehension levels for the two samples may be due to the difference in the percentage of drivers who indicated they were not sure of the meaning of the sign. Among the Mexican driver sample, 13 percent of the responses were classified as "not sure." Among the Texas drivers, the "not sure" response rate was 2 percent.

Another possible explanation is that the Mexican railroad warning sign has a different appearance (see Figure 2).

Table 6. Summary of Findings and Recommendations, General Warning Signs

Device	Code	Overall Comprehension Level[1]		Recommendation
		1st Year	2nd Year	
	W1-2 with W13-1	96.2%	92.6%	Recommend no changes in design or use.
	W6-3	94.2%	87.3%	Recommend no changes in design or use.
	W10-1	79.6%	94.2%	Recommend no changes in design or use. However, a distance plaque may be used to improve understanding of the advance message indicated by the sign. This sign should be considered for educational outreach activities.
	S1-1	86.6%	90.2%	Recommend no changes in design or use.
	CW21-4D	81.3%	89.0%	Recommend no changes in design or use.

Notes: [1]Correct plus partially correct response rates.

Comprehension of the W10-1 sign was also evaluated in two previous TTI evaluations. In both evaluations, drivers selected the meaning of the sign from a list of multiple choice responses. In both evaluations, there was a tendency of drivers to confuse the advance warning sign with the Crossbuck (R15-1) sign. In the first study (4), the correct response to the warning sign was selected by 78 percent of drivers. That response rate led to the sign being included in a second phase of study that looked at the effectiveness of alternative designs for the sign. When a distance plaque was added below the standard sign (as shown in Figure 3), comprehension improved from 81 percent for the standard sign to 91 percent for the standard sign with the distance plaque (4).

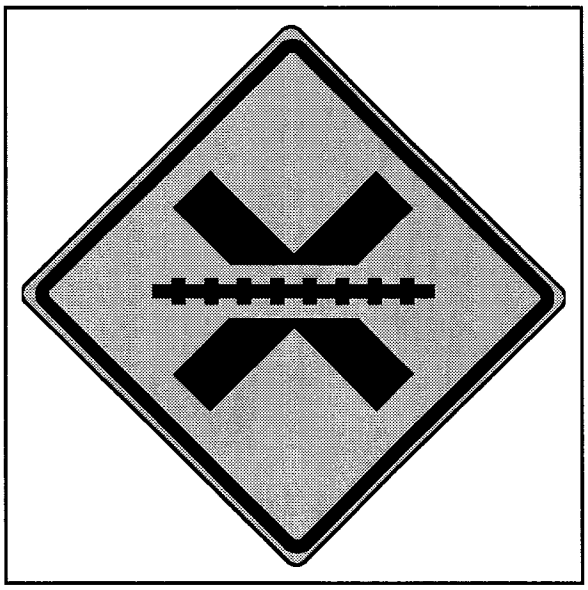


Figure 2. Mexican Railroad Warning Sign (SP-35)

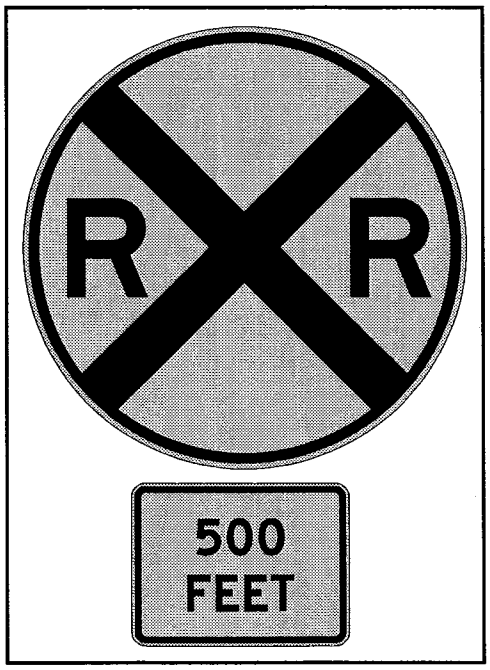


Figure 3. Alternative W10-1 Sign

Based on these results, the researchers recommend that the standard sign continue to be used. However, a distance plaque should be considered for use with the standard sign if there is concern that drivers do not understand the proper message of the sign. This sign should also be considered for educational outreach efforts with drivers in the border areas.

School Crossing Sign

The **School Crossing** sign (S1-1) was included in the first- and second-year evaluations only. Table 6 summarizes the findings associated with this sign. The overall comprehension level for the first-year survey was 87 percent. It was 90 percent for the second-year survey. There is no statistically significant difference between these levels of understanding. Based on these results, the researchers recommend no changes in the design or use of this sign.

Road Work Ahead Sign

The **Road Work Ahead** sign (CW21-4D) was included in the first- and second-year evaluations only. Table 6 summarizes the findings associated with this sign. The overall comprehension level for the first-year survey was 81 percent. It was 89 percent for the second-year survey. There is a statistically significant difference between the two overall comprehension levels. Part of the difference in the comprehension levels for the two samples may be due to the difference in the percentage of drivers that indicated they were not sure of the meaning of the sign. Among the Mexican driver sample, 15 percent of the responses were classified as "not sure." Among the Texas drivers, the "not sure" response rate was 3 percent. Another factor may be that construction warning signs are not generally used to the same extent in Mexico as they are in Texas work zones.

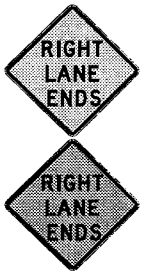
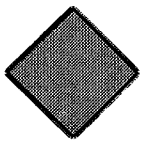
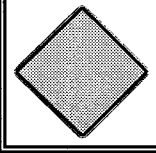
Although the results were statistically different, both samples had overall comprehension levels over 80 percent. Therefore, the researchers recommend that no changes be made to design or use

of this sign. However, this sign should also be considered for educational outreach efforts with drivers in the border areas.

Warning Sign Color

In the first- and second-year surveys, the same sign (**Right Lane Ends**, W9-1) was presented in both yellow and orange backgrounds. Drivers were then asked the difference between the two signs. Table 7 summarizes the findings associated with this sign. Table 7 also indicates the results of the third-year surveys, in which drivers were asked the meaning of a blank sign with a given shape and color. The overall comprehension level for the first-year survey was 20 percent. It was 25 percent for the second-year survey. There are no statistically significant differences between these two response rates. In the third year, the response rates for the orange sign shape were less than 20 percent in both the border and non-border areas. The yellow sign shape had a correct response rate of 32 percent. All of these comprehension levels are low. These comprehension levels are also consistent with the findings of other research. In a previous TTI research effort (4), only 58 percent of drivers selected the correct meaning of a yellow diamond from a list that included warning, directions/guidance, construction area, or not sure. Unfortunately, the meaning of sign shape and color cannot be improved through a change in the sign shape or color code. Instead, the low comprehension levels indicate a need to place greater emphasis on sign color and shape in driver education and outreach efforts.

Table 7. Summary of Findings and Recommendations, Warning Sign Shape and Color

Device	Code	Overall Comprehension Level[1]				Recommendation
		1st Year	2nd Year	3rd Year		
				Border	Non-Border	
	Difference Between Yellow and Orange Color	19.6%	25.3%	Not Included	Not Included	Recommend no changes in design or use. Sign color and shape should be considered for driver educational/outreach activities.
	Orange Diamond	Not Included	Not Included	8.9%[2, 3]	19.8%[2, 3]	
	Yellow Diamond	Not Included	Not Included	32.0%[2, 3]	Not Included	

Notes: [1]Correct plus partially correct response rates.
[2]There was no partially correct response for this sign.
[3]Response rates are for both passenger cars and trucks.

Right Lane Ends Sign

The **Right Lane Ends** sign (W9-1) was included in all three years of evaluations. This sign was included in this research study because of the findings of previous TTI research that evaluated this and related signs (6). In that effort, the eight signs shown in Figure 4 were evaluated with multiple-choice questions. The survey was administered at several locations statewide, including a border city. The results of the evaluations are shown in Table 8. Table 9 displays the results for standard signs among drivers with border characteristics (note that **Right Lane Closed 500 Ft** is a standard construction warning sign). These results indicated that word message signs were understood by the border drivers better than the standard symbol sign (W4-2). That research recommended that the word message signs be allowed to be used as an alternative to the symbol sign, and not just as a supplement to the symbol sign.

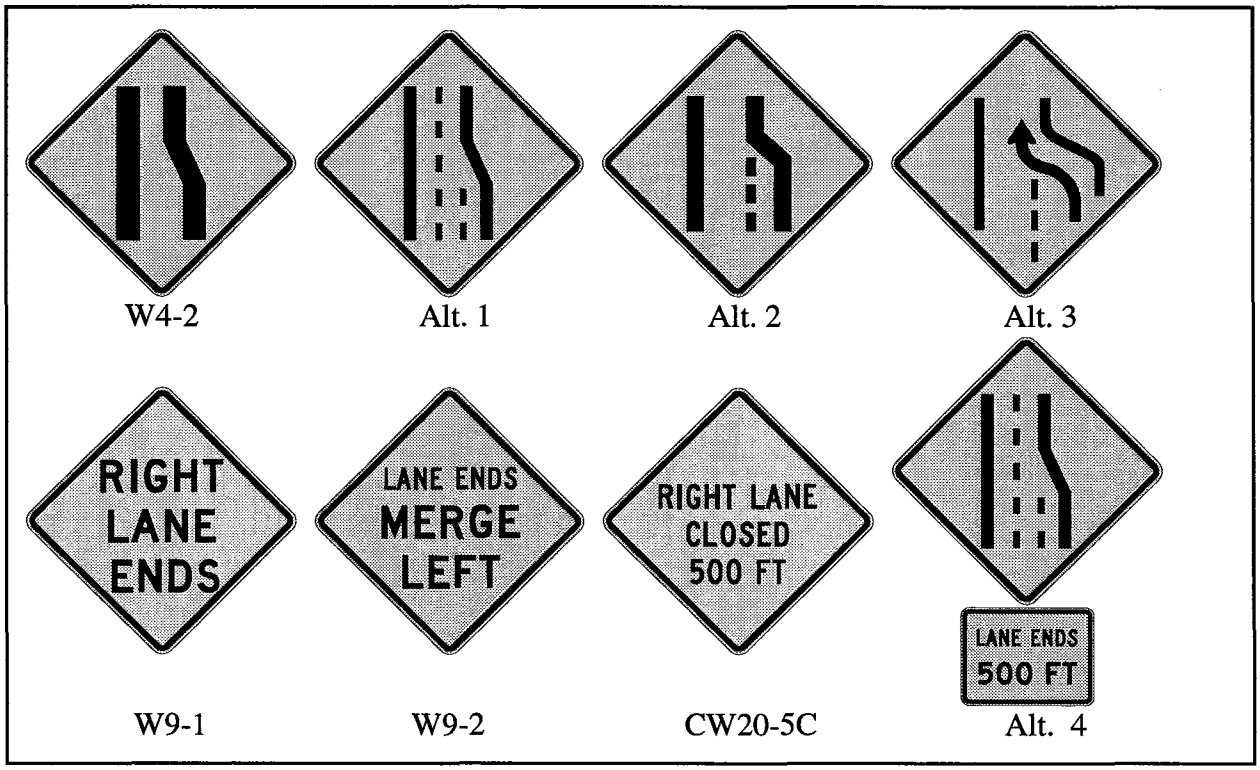
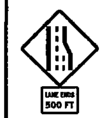


Figure 4. Lane Ends Signs Evaluated in Previous TTI Research

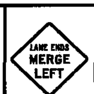
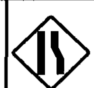
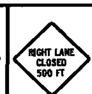
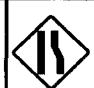
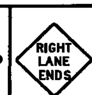
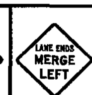
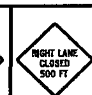
As a result of those findings, the researchers included the **Right Lane Ends** sign in the border evaluations. In the first- and second-year evaluations, the sign was a part of the question on the difference between yellow and orange signs. After drivers were asked to indicate what the different colors meant, they were asked the meaning of this sign. In the third-year surveys, drivers were asked the meaning of a yellow **Right Lane Ends** sign and three Spanish-language alternatives. Table 10 summarizes the findings associated with this sign. The correct comprehension rate for this sign in the first-year survey was 47 percent. In the second-year survey, it was 74 percent. Because of the large difference, alternative signs were developed and evaluated.

Table 8. Results of Previous TTI Research on Lane Ends Signs

SIGN ALTERNATIVE								QUESTION AND RESPONSES
								What is the most correct meaning of this sign? Circle only **ONE** answer.
71.6	***78.2***	***70.9***	***71.3***	***81.0***	***66.7***	***84.1***	***76.3***	***The lane ends and traffic in the right lane should move into the left lane.****
7.4	6.2	5.8	6.4	3.5	10.4	4.8	2.7	The lane ends and traffic in the left lane should move into the right lane.
5.7	2.6	8.5	2.1	8.6	14.6	1.1	4.8	The median between opposing traffic will end.
4.6	3.1	4.8	11.2	4.6	4.7	5.8	7.5	There is a single lane ahead for both directions of traffic.
9.7	8.3	4.8	4.3	2.3	2.6	2.1	8.1	The lane you are in will become narrower.
1.1	1.6	5.3	4.8	0.0	1.0	2.1	0.5	I am not sure what this sign means.
176	193	189	188	174	192	189	186	Sample Size

Notes: *Denotes correct response.
Source: Reference (6).

Table 9. Previous Survey Results for Lane Ends Signs Among Spanish-Language Groups

Overall Survey				Hispanic Background				El Paso Location				QUESTION AND RESPONSES
												What is the most correct meaning of this sign? Circle only **ONE** answer.
71.6	***81.0***	***66.7***	***84.1***	***55.8***	***76.7***	***53.3***	***80.5***	***62.2***	***75.7***	***72.5***	***86.5***	***The lane ends and traffic in the right lane should move into the left lane.****
7.4	3.5	10.4	4.8	16.3	7.0	11.1	14.6	10.8	8.1	7.5	5.4	The lane ends and traffic in the left lane should move into the right lane.
5.7	8.6	14.6	1.1	4.6	7.0	8.9	0.0	5.4	2.7	0.0	2.7	The median between opposing traffic will end.
4.6	4.6	4.7	5.8	7.0	7.0	15.6	0.0	8.1	8.1	12.5	2.7	There is a single lane ahead for both directions of traffic.
9.7	2.3	2.6	2.1	16.3	2.3	6.7	0.0	13.5	5.4	2.5	0.0	The lane you are in will become narrower.
1.1	0.0	1.0	2.1	0.0	0.0	4.4	4.9	0.0	0.0	5.0	2.7	I am not sure what this sign means.
176	174	192	189	43	43	45	41	37	37	40	37	Sample Size

Notes: *Denotes correct response.
Source: Reference (6).

Table 10. Summary of Findings and Recommendations, Right Lane Ends Signs

Device	Code	Overall Comprehension Level[1]					Recommendation
		1st Year	2nd Year	3rd Year			
				Border		Non-Border	
	W9-1	46.5%[2]	74.3%[2]	68.8% (Spanish)	100.0 (English)	92.6%	Recommend no changes in design or use. Alternative A may be used to supplement this sign.
	Alt. A	Not Included	Not Included	88.4% (Spanish)	62.7% (English)	Not Included	This sign may be used to supplement the standard sign.
	Alt. B	Not Included	Not Included	83.3% (Spanish)	59.6% (English)	Not Included	Not recommended for implementation.
	Alt. C	Not Included	Not Included	85.3% (Spanish)	34.0% (English)	Not Included	Not recommended for implementation.

Notes: [1]Correct plus partially correct response rates.
[2]No partially correct response rates.

In the third year, the standard sign had overall comprehension levels of 69 percent for the border drivers speaking Spanish, 100 percent for the border drivers speaking English, and 93 percent for the non-border drivers. The Spanish-language signs were better understood among the Spanish-speaking driver sample, with all three signs having overall comprehension levels near 85 percent. There was no statistically significant difference between the comprehension levels of these three signs. Among the English-speaking border drivers, the overall comprehension levels of the three Spanish-language signs ranged from 34 to 63 percent. The **Carril Derecho Termina** sign had slightly higher comprehension levels than the **Carril Derecho Cerrado** sign, although the differences are not statistically significant.

Based on the results of TTI research on this and related signs, the researchers recommend that the **Carril Derecho Termina** sign be used as a supplement to the **Right Lane Ends** sign where engineering judgement indicates safety or compliance concerns in a border district. When used, the supplemental Spanish-legend sign should be installed downstream of the standard sign. The placement distance between the two signs should be based on the warning sign placement distances in Table 2C-1 of the Texas MUTCD (5). For a 70 mph speed, this distance is 925 feet. Furthermore, the researchers reemphasize the recommendations of previous research (6):

*The Texas MUTCD should allow either of the two word message signs [**Right Lane Ends** or **Right Lane Closed 500 Ft**] to be used as the primary warning sign for a lane reduction*

instead of the standard symbol sign [W4-2]. When only one sign is installed, the Texas MUTCD should allow one of these word message signs to be used. When more than one sign is used, the symbol sign should be used to supplement the word message sign. The ***Right Lane Closed 500 Ft*** *sign should be added to the Texas MUTCD as a general warning sign with a yellow background. The MUTCD language for this sign should provide an option that allows the distance to be displayed in a supplemental plaque instead of in the sign legend.*

Truck Signs

A significant portion of the effort on this research project was devoted to evaluating how well drivers of heavy vehicles understood signs targeted toward them. The truck-related signs addressed in this research included the **Truck Day/Night Speed Limit**, **Weight Limit**, **Weigh Station**, **Hill**, **Low Clearance**, **Load Zoned Bridge**, **Hazardous Cargo Route**, and **Hazardous Cargo Prohibited**. The following sections summarize the first-, second-, and third-year findings for each of these signs, along with the overall recommendations regarding the design and use of the signs.

In the third-year evaluations, the sample size of English-speaking truck drivers at the border locations was very small. As a result, the results for that sample are not meaningful and are not presented in this summary. In the results for the truck signs, the border sample represents truck drivers who speak Spanish, while the non-border sample represents drivers who speak English.

Truck Speed Limit

The **Truck Speed Limit** sign (R2-2a) combined with a **Night Speed Limit** sign (R2-3) was included in the first- and second-year evaluations. Table 11 summarizes the findings associated with this sign. Several alternative designs for this sign were evaluated in the second-year survey. The overall comprehension level of the speed limit message of this sign (correct plus partially correct) was 94 percent for the Mexican drivers (first year) and 99 percent for the Texas drivers (second year). The alternative designs have overall comprehension levels over 98 percent. Understanding of the night speed message was between 80 and 90 percent among the four signs. Understanding of the fact that the speed was in miles per hour was over 94 percent for all four signs.

Based on these results, the researchers recommend that no changes be made to design or use of this sign. This is consistent with the recommendation for the standard speed limit sign, as described on page 6.

Table 11. Summary of Findings and Recommendations, Truck Speed Limit Signs

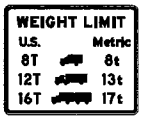
Device	Code	Overall Comprehension Level[1]		Recommendation
		1st Year	2nd Year	
	R2-2a and R2-3	93.8%	98.5%	Recommend no changes in design or use.
	Alt. A	Not Included	100.0%	Not recommended for implementation.
	Alt. B	Not Included	98.5%	Not recommended for implementation.
	Alt. C	Not Included	100.0%	Not recommended for implementation.

Notes: These signs were addressed in the first- and/or second-year surveys only.

Weight Limit Sign

The **Weight Limit** sign (R12-1) was addressed in all three years of the research project. This is one of 19 regulatory signs contained in the Texas MUTCD that can be used to inform drivers of a limit on vehicular weight. The large number of signs indicates the complexities associated with conveying weight information to drivers. Alternatives to this sign that were part of the evaluations included several Spanish-language signs, signs equivalent to those used in other countries, and signs with metric units. Table 12 summarizes the findings associated with these signs.

Table 12. Summary of Findings and Recommendations, Weight Limit Signs

Device	Code	Overall Comprehension Level[1]				Recommendation
		1st Year	2nd Year	3rd Year		
				Border	Non-Border	
	R12-1	86.0%	81.6%	74.7%	98.1%	Recommend no changes in design or use. Alternative F may be used to supplement this sign.
	Alt. A	Not Included	22.8%	Not Included	Not Included	Not recommended for implementation.
	Alt. B	Not Included	7.7%	Not Included	Not Included	Not recommended for implementation.
	Alt. C	Not Included	50.0%	Not Included	Not Included	Not recommended for implementation.
	Alt. D	Not Included	Not Included	94.7%	Not Included	Not recommended for implementation.
	Alt. E	Not Included	Not Included	91.7%	Not Included	Not recommended for implementation.
	Alt. F	Not Included	Not Included	93.2%	Not Included	This sign may be used to supplement the standard sign.

Notes: [1]Correct plus partially correct response rates.

Among the first-year Mexican truck drivers, the overall comprehension level for the standard sign was 86 percent. Among the second-year Texas truck drivers, the overall comprehension level was 82 percent. Alternatives presented in the second-year survey provided various means of communicating the weight limits using metric units. The overall comprehension levels of these signs ranged from 8 to 50 percent.

In the third year, the standard sign (English language) had an overall comprehension level of 75 percent for the border drivers and 98 percent for the non-border areas. The Spanish-language alternatives had overall comprehension levels between 92 and 95 percent. None of the three alternative signs is statistically significantly better than any other alternative when comparing the overall comprehension levels. However, the relative performance of the Spanish-language signs is more apparent when the correct response rate is compared. Table 13 compares the third-year correct and partially correct response rates for all three of these signs for the Spanish-speaking driver

sample. A more visible difference between the alternatives is identified by looking at the correct comprehension rate. The **Peso Maximo** sign emerges as the best understood by approximately 10 percent. Although the difference is not statistically significant, it provides a better indication of the relative performance than a comparison of the overall comprehension levels.

Table 13. Comparison of Third-Year Results for Weight Limit Sign Alternatives

Sign	Correct	Partially Correct	Correct + Partially Correct	Sample Size
	42.1%	52.6%	94.7%	76
	54.2%	37.5%	91.7%	72
	64.9%	28.4%	93.2%	74

Response rates and sample sizes do not include indeterminate (unknown) responses.

The results indicate some inconsistencies in the comprehension level of the standard sign among border truck drivers. In the first year, the overall comprehension level was 86 percent, while it was 75 percent in the third year. The difference is statistically significant. The results do not conclusively indicate a need to make a change in the standard sign. Based on the results of the evaluations, the standard sign should continue to be used for all applications. Where engineering judgement indicates safety or compliance concerns in a border district, the **Peso Maximo – 10 Tons** sign may be installed to supplement the standard sign. When used, the supplemental Spanish-legend sign should be mounted on the same post as the standard sign. The standard sign should be on top in a vertical arrangement and on the left in a horizontal arrangement.

It should be noted that the Texas MUTCD contains 19 different regulatory signs for indicating various types of weight limits. Although this research has identified a Spanish-legend sign that appears to be effective in communicating a 10 ton weight limit to Spanish-speaking truck drivers, this one sign cannot serve to replace all 19 of the English-language signs. The supplemental Spanish sign should be used with care. There is a need for additional research to analyze comprehension of the various regulatory weight limit signs among both border and non-border drivers.

Weigh Station Sign

The **Weigh Station** sign (D8-2) was addressed in all three years of the research project. The sign was not included in the non-border truck driver sample, as that survey was conducted at a weigh station. As such, those drivers would not have provided an appropriate indication of driver understanding of the sign. This is one of several types of signs associated with weigh stations, including regulatory and warning signs. Alternatives to this sign that were part of the evaluations included Spanish-language and symbol signs. Table 14 summarizes the findings associated with these signs.

Table 14. Summary of Findings and Recommendations, Weigh Station Signs

Device	Code	Overall Comprehension Level[1]				Recommendation
		1st Year	2nd Year	3rd Year		
				Border	Non-Border[2]	
	D8-2	33.0%	36.3%	18.8%	N/A	Recommend no changes in design or use. Alternative A may be used to supplement the standard sign.
	Alt. A	Not Included	98.5%	Not Included	N/A	This sign may be used to supplement to the standard sign.
	Alt. B	Not Included	42.5%	Not Included	N/A	Not recommended for implementation.
	Alt. C	Not Included	Not Included	45.9%	N/A	Not recommended for implementation.
	Alt. D	Not Included	Not Included	30.6%	N/A	Not recommended for implementation.
	Alt. E	Not Included	Not Included	42.0%	N/A	Not recommended for implementation.

Notes: [1]Correct plus partially correct response rates.
[2]This sign was not administered at the non-border location because it was at a weigh station.

Among the first-year Mexican truck drivers, the overall comprehension level for the standard sign was 33 percent. Among the second-year Texas truck drivers, the overall comprehension level was 36 percent. In the third year, the overall comprehension level among the Spanish-speaking border drivers was 19 percent.

One of the alternatives presented in the second-year survey combined English and Spanish languages in the same sign legend. That sign had an overall comprehension level of 99 percent. The other alternatives evaluated in the second or third year included a symbol sign and signs with only a Spanish legend. The overall comprehension levels of these signs ranged between 31 and 46 percent.

Among the six signs evaluated during the three years of evaluations, only the sign **Weigh Station (Bascula) Next Right** exhibited a high level of comprehension. This is the only sign evaluated in this project which contained a dual language legend. The high level of comprehension (99 percent) indicates that this sign should be recommended for use as a supplement to the standard sign where engineering judgement indicates safety or compliance concerns in a border district.

Hill Sign

The **Hill** sign (W7-1) was included in the first-year truck driver evaluation only. Table 15 summarizes the findings associated with this sign. The overall comprehension level for the first-year survey was 88 percent. Based on these results, the researchers recommend no changes in the design or use of this sign.

Table 15. Summary of Findings and Recommendations, Hill Sign

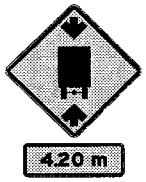
Device	Code	1st Year	2nd Year	Recommendation
	W7-1	86.7%	Not Included	Recommend no changes in design or use.

Low Clearance Sign

The **Low Clearance** sign (W12-2T) was included in both of the first two years of the evaluation. Metric-based alternatives were also evaluated in the second year. One of these alternatives was the Mexican version of the warning sign. Table 16 summarizes the findings associated with this sign. Comprehension of the standard sign was 79 percent in the first year and 83 percent in the second year. The metric alternatives had second-year comprehension levels of 84 to 91 percent. There are no statistically significant differences in the overall comprehension levels of any of these signs. As a result, it is not possible to state that any one alternative is more effective than any other sign.

At the time that this research effort began, the U.S. federal government was encouraging state departments of transportation to implement the metric system as the basis for measurement. Although the transition to metric units did not encompass sign legends, it appeared that sign legends might ultimately be converted to metric units. As this project progressed, the transition to metric units has slowed considerably and even retreated in many areas. Consequently, the likelihood of using metric units in sign legends is considered remote anytime in the foreseeable future. Based on the survey results and the present use of metric units in the U.S. transportation community, the researchers recommend that no changes be made in the design or use of this sign.

Table 16. Summary of Findings and Recommendations, Low Clearance Signs

Device	Code	Overall Comprehension Level[1]		Recommendation
		1st Year	2nd Year	
	W12-2T	79.0%	83.1%	Recommend no changes in design or use.
	Alt. A	Not Included	89.4%	Not recommended for implementation.
	Alt. B	Not Included	90.8%	Not recommended for implementation.
	Alt. C	Not Included	83.9%	Not recommended for implementation.

Notes: [1]Correct plus partially correct response rates.

Load Zoned Bridge Sign

The **Load Zoned Bridge** sign (W12-5) was included in all three years of the evaluations. Alternative legends were evaluated in the second- and third-year evaluations. These alternatives included both Spanish- and English-language legends. Overall comprehension of the standard sign was less than 10 percent in the first year. In the second year, the evaluation criteria were revised and the overall comprehension level was improved. Appendices A and B provide details on the criteria change. The results of the evaluations for this sign are provided in Table 17.

Table 17. Summary of Findings and Recommendations, Load Zoned Bridge Signs

Device	Code	Overall Comprehension Level[1]				Recommendation
		1st Year	2nd Year	3rd Year		
				Border	Non-Border	
	W12-5	7.3%[2]	38.4%	25.4%	98.1%	Recommend no changes in design or use. Alternative A may be used to supplement this sign.
	Alt. A	Not Included	93.7%	98.7%	Not Included	This sign may be used to supplement the standard sign.
	Alt. B	Not Included	80.0%	Not Included	Not Included	Not recommended for implementation.
	Alt. C	Not Included	Not Included	41.7%	96.1%	Not recommended for implementation.
	Alt. D	Not Included	Not Included	90.7%	Not Included	Not recommended for implementation.

Notes: [1]Correct plus partially correct response rates.
[2]The evaluation criteria were revised following the first-year evaluation.

The results indicate that English-language signs had comprehension levels over 95 percent among the English-speaking truck drivers while the Spanish-language signs had comprehension levels over 90 percent for the Spanish-speaking truck drivers. The English-language signs had comprehension levels below 50 percent among the Spanish-speaking drivers.

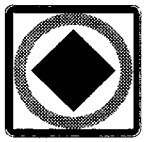
Based on these results, the researchers recommend that the **Puente De Peso Limitado** sign be used as a supplement to the **Load Zoned Bridge** sign where engineering judgement indicates safety or compliance concerns in a border district. When used, the supplemental Spanish-legend sign may be installed downstream of the standard sign or on the same post. The adjacent installation is appropriate where the sign is used at an intersection to prevent overweight vehicles from entering the roadway. If the signs are installed on the same post, the standard sign should appear at the top of a vertical arrangement or on the left of a horizontal arrangement. When used sequentially, the placement distance between the two signs should be based on the warning sign placement distances in Table 2C-1 of the Texas MUTCD (5). For a 70 mph speed, this distance is 925 feet.

As with the **Weight Limit** and **Weigh Station** signs, the **Load Zoned Bridge** sign is one of many signs that inform truck drivers of weight restrictions within the highway network. Due to the variety of signs that address weight restrictions, the researchers recommend that future research focus on the issue of signing for weight restrictions and truck driver understanding of this system of signs. The research should focus upon the development of a more effective English-language or symbol sign.

Hazardous Cargo Signs

Hazardous cargo signs were evaluated in all three years of the research project. Both the **Hazardous Cargo Route** (R14-2) and the **Hazardous Cargo Prohibited** (R14-3) signs were included in the evaluations. Table 18 summarizes the results of the **Hazardous Cargo Route** signs and Table 19 summarizes the results for the **Hazardous Cargo Prohibited** signs. Two of the alternatives use a diamond symbol within the circle instead of letters. The black diamond is the symbol used in Canada. The multicolored diamond is intended to represent the National Fire Protection Association chemical hazard label. The top diamond is red, the left diamond is blue, the right diamond is yellow, and the bottom diamond is white.

Table 18. Summary of Findings and Recommendations, Hazardous Cargo Route Signs

Device	Code	Overall Comprehension Level[1]				Recommendation
		1st Year	2nd Year	3rd Year		
				Border	Non-Border	
	R14-2	31.4%[2]	12.3%[2]	4.5%	79.8%	Recommend no changes in design or use. Further evaluations should be conducted.
	Alt. A	Not Included	3.0%[2]	Not Included	Not Included	Not recommended for implementation.
	Alt. B	Not Included	29.9%[2]	12.1%	37.7%	Not recommended for implementation.
	Alt. C	Not Included	Not Included	4.5%	80.8%	Not recommended for implementation. Should be included in future evaluations.

Notes: [1]Correct plus partially correct response rates.
[2]There was no partially correct response for this sign.
All signs have a green circle.

Table 19. Summary of Findings and Recommendations, Hazardous Cargo Prohibited Signs

Device	Code	Overall Comprehension Level[1]				Recommendation
		1st Year	2nd Year	3rd Year		
				Border	Non-Border	
	R14-3	39.5%	21.9%	Not Included	Not Included	Recommend no changes in design or use. Further evaluations should be conducted.
	Alt. A	Not Included	30.7%	Not Included	Not Included	Not recommended for implementation.
	Alt. B	Not Included	35.8%	Not Included	Not Included	Not recommended for implementation.
	Alt. C	Not Included	Not Included	1.5%	80.7%	Not recommended for implementation. Should be included in future evaluations.

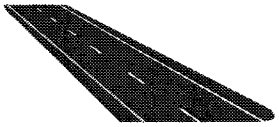
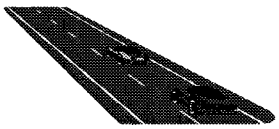
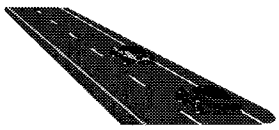
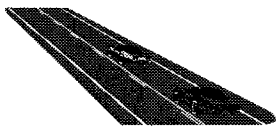
Notes: [1]Correct plus partially correct response rates.
All signs have a red circle and slash/underline.

In general, none of the standard signs or alternatives performed well at the border locations. The HC and HM signs had overall comprehension levels near 80 percent. However, the difference between the standard HC sign and the HM alternative was not statistically significant. Based on these results, the researchers recommend no changes in the design or use of these signs. However, the issue of communicating hazardous cargo information to drivers is a significant issue and deserves further evaluation.

MARKINGS

The first- and second-year surveys included several questions to assess how well drivers understand pavement markings. The markings included broken yellow and white lines and a no passing line. Questions addressed one-way versus two-way and the passing restriction messages of the markings. Table 20 presents the results of the evaluations.

Table 20. Summary of Findings and Recommendations, Fasten Safety Belt Signs

Device	Code	Overall Comprehension Level[1]		Recommendation
		1st Year	2nd Year	
 Yellow centerline	One-Way vs. Two-Way	72.2%[2]	83.2%[2]	The meaning of pavement markings should receive greater emphasis in driver education and outreach efforts.
 White lane line		51.5%[2]	48.3%[2]	
 Yellow centerline	Passing	74.8%	78.4%	
 White lane line		81.8%[2]	92.9%[2]	
 No passing marking	No Passing Zone	84.1%[2]	89.0%[2]	

Notes: [1]Correct plus partially correct response rates.
[2]There was no partially correct response for this marking.

One-Way Versus Two-Way Message

Previous TTI research (4) has found that a significant proportion of drivers do not understand that a yellow broken line indicates a road with two-way traffic while a white broken line indicates a road with one-way traffic. In this part of the survey, drivers were presented with a two-lane road with either a white or yellow broken line dividing the two lanes. There were no vehicles on the road. Drivers were asked if the road was one-way or two-way. Correct responses to the yellow line road was 72 and 83 percent for the Mexican and Texas drivers, respectively. However, for the white line, correct responses were 52 and 48 percent, respectively. Previous TTI research (4) has also found a lack of understanding of the one-way versus two-way message of pavement marking color. There is little that can be done with the design of these markings to improve driver understanding of the one-way versus two-way message. The findings indicate the need to emphasize this message in driver education and outreach activities.

One treatment that should be considered for evaluation in future research is the use of pavement arrows at critical locations to indicate one-way versus two-way traffic. One example of a location where such an application might have value is on two-way frontage roads near the vicinity of a freeway exit ramp. The effectiveness of this application needs to be determined from field evaluations.

Passing Message

Three images were used to evaluate driver understanding of the passing message associated with the different markings. In all three images, there were two cars in the same lane, and drivers were asked if the second car was allowed to pass the first car.

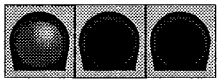
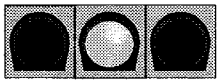
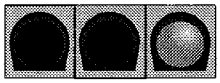
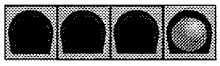
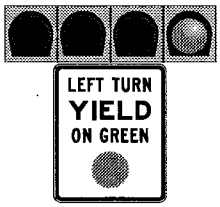
For the broken yellow centerline, the correct responses were 75 and 78 percent for the Mexican and Texas drivers, respectively. For the broken white lane line, the correct responses were 82 and 93 percent, respectively. For the solid yellow no passing zone line, the correct responses were 84 and 89 percent, respectively.

The responses to the passing restriction message of the markings were higher than the one-way versus two-way message of the markings. In particular, understanding of the passing restriction (no passing line) was among the highest of the pavement marking comprehension results. Based on these results, the researchers do not recommend any changes in the design or use of the pavement markings. However, as with the one-way/two-way message issue, the passing message of markings should also be included in driver education/outreach efforts.

SIGNALS

The first- and second-year surveys included several questions to assess how well drivers understand traffic signals and left turn signal signs. The signals included the three colors of circular (ball) indications. Left turn indications included the arrow and ball indications. Left turn indications were presented with and without signs. Table 21 presents the results of the evaluations.

Table 21. Summary of Findings and Recommendations, Fasten Safety Belt Signs

Device	Code	Overall Comprehension Level[1]		Recommendation
		1st Year	2nd Year	
	Red Ball	97.7%[2]	99.5%[2]	Recommend no changes in the design or use of these indications.
	Yellow Ball	97.7%[2]	98.8%[2]	
	Green Ball Indication for Through	97.6%[2]	99.5%[2]	
	Green Ball Indication for Left Turn	79.0%	86.0%	Recommend no changes in design or use.
		78.2%	87.8%	Recommend no changes in design or use.
	Green Arrow Indication for Left Turn	80.8%	85.9%	Recommend no changes in design or use.
		72.1%	94.6%	The Left Turn Yield on Green Ball sign should be used instead of this sign.

Notes: [1]Correct plus partially correct response rates.
[2]There was no partially correct response for this marking.

Through Movement Signals

In each of the first two years, drivers were asked the meaning of the red, yellow, and green circular indications in a traffic signal. The correct comprehension responses were 98 percent or higher for all indications in both samples. Based on these results, the researchers recommend that no changes be made in the design or use of the round traffic signal indications.

Left Turn Movement Signals

In the first two surveys, drivers were presented with four different left turn signal indication scenarios. There were two with a left turn arrow and two with a green ball. One of the left arrow scenarios included a **Protected Left on Green Arrow** sign (R10-9). One of the green ball scenarios included a **Left Turn Yield on Green Ball** sign (R10-12). The correct response rates for these four scenarios ranged from 72 to 100 percent. In all cases, the Texas driver response rates were higher

than the Mexican driver rates and the differences were statistically significantly different. The differences between the Mexican and Texas drivers were smallest for those indications with no signs. The **Left Turn Yield on Green Ball** indication had little impact on the comprehension of the message, as the difference between the two scenarios among the Mexican drivers was not statistically significant. Previous TTI research also found that the **Left Turn Yield on Green Ball** sign was better understood than the **Protected Left on Green Arrow** sign (4).

Based on these results, the researchers recommend that the **Left Turn Yield on Green Ball** sign (R10-12) be used as the primary sign for informing drivers of protected/permitted left turn signal operation. This issue should also receive greater emphasis in driver education/outreach efforts.

CHAPTER 3
SUMMARY OF RECOMMENDATIONS

The recommendations presented in the previous chapter can be divided into five categories as described below. In this chapter, each of the standard devices evaluated in this research is presented according to the related recommendation(s):

- **No changes to current practice** - The evaluations indicated that the standard device was adequately understood or better understood than the alternatives evaluated in this research. As a result, the current design or use of the devices should not be changed.
- **Use of alternative sign as a supplement** - The evaluations indicated that a Spanish-language sign may be used to supplement the standard sign.
- **Increased emphasis in driver education and outreach** - The evaluations indicated a need to improve comprehension, but there are no engineering improvements that can be made to enhance comprehension. As a result, the meaning of the device should be emphasized in driver education, training, and outreach activities.
- **Modification in design or use of standard sign** - The evaluations indicated that the design or use of the standard sign should be modified. This may include use of a different sign or a minor change in the design of the sign.
- **Evaluate in future research efforts** - The evaluations identified a device that should be evaluated in greater detail in future research efforts.

NO CHANGES TO CURRENT PRACTICE

For virtually every device, the evaluations determined that the standard device should continue to be used. However, there are some qualifications for some of the devices, including the use of supplemental legends or plaques, emphasis in driver education, or recommendations for future research. The devices for which the design or use should not change are presented in Table 22.

SUPPLEMENTAL USE OF ALTERNATIVE SIGN

For several signs in the evaluations, the researchers found that a Spanish-language sign, or a bilingual sign, improved comprehension of the message in the border areas. In these cases, the Spanish-language or bilingual sign should be used as a supplement to the standard sign. The standard sign and supplemental sign recommended for implementation are presented in Table 23.

INCREASED EMPHASIS IN EDUCATION

For several of the devices evaluated in this research effort, engineering improvements in the design or use of a devices are not likely to lead to improved comprehension. The only effective means of improving understanding of these devices is through driver education, training, or outreach efforts. Table 24 presents these devices. A current TxDOT/TTI research project (1794-Driver Education Program for Traffic Control Devices) is focusing upon driver education for traffic control

devices and will consider the findings of this research in the development of driver education curriculums.

Table 22. Devices with No Recommendations for Changes in Design or Use

Name	Stop	Yield	Speed Limit	Do Not Enter	One Way	Curve with Advisory Speed Plate
Code	R1-1	R1-2	R2-1 with R1-3	R5-1	R6-1	W1-2 with W13-1
Illustration						
Name	Two-Way Traffic	Railroad Advance	School Crossing	Road Work Ahead	Truck Speed Limit	Hill
Code	W6-3	W10-1	S1-1	CW21-4D	R2-2a with R2-3	W7-1
Illustration						
Name	Low Clearance	Hazardous Cargo Route	Hazardous Cargo Prohibited	Red Ball	Yellow Ball	Green Ball
Code	W12-2T	R14-2	R14-3	N/A	N/A	N/A
Illustration						
Name	Green Ball for Left Turn	Green Ball for Left Turn with R10-12	Green Arrow for Left Turn	Broken Yellow Centerline	White Lane Line	No Passing Line
Illustration				not illustrated		

Table 23. Devices with Recommendations for Spanish-Language Supplement

Name	Stop for School Bus	Fasten Safety Belt	Right Lane Ends	Weight Limit	Weigh Station	Load Zoned Bridge
Code	R19-1	R19-8	W9-1	R12-1	D8-2	W12-5
Standard						
Spanish-Language Supplement						

Table 24. Devices Recommended for Emphasis in Driver Education

Name	Railroad Advance		
Code	W10-1		
Illustration		Sign shape and color	All pavement markings
Emphasis	Difference between advance and crossing signs.	Traffic sign color and shape code.	Difference between yellow and white markings.

CHANGE IN DESIGN OR USE

For a small number of signs, the researchers recommend a change in the design or use of the standard sign. For all of these devices, the recommendations are consistent with the recommendations of a previous TxDOT/TTI research study on driver understanding of traffic control devices (4, 6). The signs that fall within this classification are presented in Table 25.

ADDITIONAL RESEARCH

Finally, the researchers have identified several devices that warrant further evaluation in future research efforts. Table 26 presents these signs. For the **Stop for School Bus When Red Lights Flashing** sign, the comprehension results indicate that this sign has a slightly higher comprehension level than the standard sign. However, the non-border survey sample for this sign was not large enough to justify its implementation. A more comprehensive evaluation may indicate the benefits of this sign. For the hazardous cargo signs, the research was not able to identify sign designs that

were significantly better understood than the current standard signs. However, comprehension of the standard signs is sufficiently low to justify further evaluation of alternatives. Finally, this research addressed several weight-related regulatory, warning, and guide signs. But those evaluated in this research reflect only a small percentage of the total number of weight-related signs. The issue has sufficient complexity and interdependency that an evaluation of the total system should be evaluated. Project statements for these future research efforts are provided in Appendix E.

Table 25. Devices with Recommendations for Changes in Design or Use

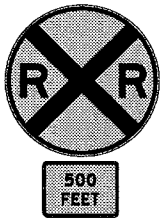
Name	Railroad Advance Sign with Supplemental Distance Plaque	Right Lane Closed 500 Ft	Left Turn Arrow with Protected Left on Green Arrow sign
Code	W10-1	W20-5C	R10-9
Illustration			
Change	Use distance plaque.	Use as an alternate to the Right Lane Ends sign.	Not recommended. Use R10-12 sign instead.

Table 26. Devices Recommended for Additional Research

Name	Stop for School Bus	Hazardous Cargo Route	Hazardous Cargo Prohibited	Weight-Related Signs: Regulatory, Warning, and Guide
Illustration				

CHAPTER 4
REFERENCES

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2. Picha, D.L., H.G. Hawkins, Jr., A.K. Vizcarra, and R.A. Donovan. *Assessment of Existing and Alternative Traffic Control Devices in Texas Border Areas,* Research Report 1274-2, Texas Transportation Institute, College Station, Texas, February 1998.
3. Hawkins, Jr., H.G., D.C. Kreis, and M.A. Knodler. *Evaluation of Alternative Traffic Signs for Use in Texas Border Areas.* Research Project 1274-3, Texas Transportation Institute, College Station, Texas, March 1999, draft.
4. Hawkins, Jr., H.G., K.N. Womack, and J.M. Mounce. *Motorist Understanding of Traffic Control Devices: Study Results and Recommendations.* Research Report 1261-4, Texas Transportation Institute, College Station, Texas, March 1994.
5. *Texas Manual on Uniform Traffic Control Devices.* Texas Department of Highways and Public Transportation, Austin, Texas, 1980, revised through 1997.
6. Picha, D.L., H.G. Hawkins, Jr., and K.N. Womack. *Motorist Understanding of Alternative Designs for Traffic Signs.* Research Report 1261-5F. Texas Transportation Institute, College Station, Texas, November 1995.

APPENDIX A
FIRST-YEAR SURVEY RESULTS

This appendix presents the devices, questions, response concepts, response rates, and sample sizes for the devices that were evaluated in the first-year survey. The tables in this appendix are essentially the same as the tables in Appendix B of the first-year report (1).

Table 27. First-Year Mexican Driver Survey Results for Regulatory Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If answer is only *STOP* a. What does this sign mean in Spanish? and/or b. What does *Stop* mean?	Must come to a complete halt (or stop or alto or pare)	No acceptable response	98.7	N/A	0.5	0.2	0.7	600
	What does this sign mean? If answer is only *YIELD* a. What does this sign mean in Spanish? and/or b. What does *Yield* mean?	Must give/cede/yield right-of-way (or cede el paso, de el paso) to traffic on the other roadway	No acceptable response	63.9	N/A	21.5	13.6	1.0	604
	What does this sign mean? For all responses: a. Is the speed in *kilometers per hour* or *miles per hour*?	Needs both concepts: maximum speed/ maximum velocity/speed limit ***and*** units (mph or miles)	Either concept: maximum speed/ maximum velocity/speed limit ***or*** units (mph or miles)	82.3	15.2	1.3	0.5	0.7	599
	b. Why are there two different numbers?	One is day speed and other is night (after dark) speed	No acceptable response	82.5	N/A	9.7	6.1	1.7	462
	What does this sign mean?	Must not enter the roadway from this direction, wrong way, or no entry	No acceptable responses	90.7	N/A	4.6	3.4	1.2	581
	What does this sign mean?	Right only or one-way	No acceptable response	83.3	N/A	13.8	1.6	1.3	558

Table 27. First-Year Mexican Driver Survey Results for Regulatory Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Stop for school bus loading, unloading or if the bus lights are flashing	School bus	57.9	24.2	14.6	3.3	0.0	553
	For all responses: a. When do you have to stop for a school bus?	When the red lights are flashing or whenever the bus is loading or unloading	No acceptable response	64.6	N/A	27.4	5.4	2.5	277
	What does this sign mean?	Must wear safety/seat belt ***and*** it is state law	Wear safety/seat belt or just seat belt	33.2	23.2	5.5	36.6	1.5	587
	For truck drivers only: a. Does this sign apply to you?	Yes	No acceptable response	89.2	N/A	7.0	1.3	2.6	157

Table 28. First-Year Mexican Driver Survey Results for Warning Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Road curves/turns/bends ***and*** recommended speed is 35 mph (must give units). Not speed limit or maximum speed	Either road curves/turns/bends ***or*** recommended/ maximum speed (or speed limit) is 35 mph	65.4	30.8	2.5	1.0	0.4	526
	If "*CURVE/TURN*" is not part of the response: a. What does the arrow mean?	Shows the change in road direction, direction you should drive	No acceptable response	76.9	N/A	20.0	1.6	1.6	65
	If "*SPEED*" is not part of the response: b. What does the "35" mean?	Recommended speed in mph (miles)	Speed limit or maximum speed	44.1	48.7	4.5	1.8	0.9	111
	Following any response that mentions "*SPEED*": c. Is this speed in *kilometers per hour* or *miles per hour*?	mph (miles)	No acceptable response	86.4	N/A	11.4	0.0	2.3	44
	What does this sign mean?	Two-way traffic or traffic going in both/opposing directions	No median between traffic	93.3	0.6	4.1	1.9	0.2	534
	What does this sign mean?	Railroad crossing ahead	Just railroad crossing or train	39.1	40.5	6.5	12.8	1.2	603
	What does this sign mean?	School crosswalk	Crosswalk or pedestrian crosswalk	52.3	34.3	11.6	1.5	0.4	545
	If the response does not include "*SCHOOL*": a. Who would you expect to see when you see this sign?	Students or children or school-age pedestrians	No acceptable response	68.5	N/A	29.1	1.6	0.8	127
	If the response does not include "*CROSSING*": b. Where would you expect to see them?	At or near the crosswalk	No acceptable response	63.9	N/A	32.8	3.3	0.0	61

Table 29. First-Year Mexican Driver Survey Results for Other Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Any response that identifies construction, road work, or workers in or near the highway	Slow down without mention of road work	80.3	1.0	2.9	14.9	0.9	579
	For all responses: a. What should you do when you see this sign?	Watch for road or construction work and be prepared to slow down	Slow down	64.5	28.7	5.8	0.0	1.1	380
	For simple answers: b. Anything else?	Record verbatim	N/A	88.9	N/A	0.0	0.0	11.1	9
	Why are these two signs different?	The orange sign indicates construction, ***and*** the yellow sign is a warning	Either the orange sign indicates construction, ***or*** the yellow sign is a warning	8.4	11.2	16.9	62.3	1.2	498
	For all responses: a. What do these signs mean?	Move to the left lane ***or*** right lane ends	No acceptable response	46.5	N/A	19.3	32.6	1.5	331

Table 30. First-Year Mexican Driver Survey Results for Truck-Related Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If the primary answer is "*SPEED LIMIT*" without specifying "*TRUCKS*": a. What types of vehicles must obey this speed limit?	Maximum speed/velocity for trucks ***and*** units (60 miles per hour)	Maximum speed/velocity for trucks ***or*** units (60 miles per hour)	63.9	29.9	4.2	1.4	0.7	144
	If the primary answer is "*SPEED LIMIT FOR TRUCKS*": b. Is the speed in *kilometers per hour* or *miles per hour*?	mph	No acceptable response	92.0	N/A	7.1	0.9	0.0	112
	For all responses: c. Why are there two different numbers?	60 is the day speed, and 55 is the night speed or speed after dark	No acceptable response	65.5	N/A	31.0	2.6	0.9	116
	What does this sign mean? For all responses: a. What are the units of measurement?	Vertical clearance/clear height ***and*** units (13 feet 6 inches)	Vertical clearance/clear height ***or*** units (13 feet 6 inches)	67.7	11.3	9.0	9.8	2.3	133
	What does this sign mean? For all responses: a. How much is a ton?	Maximum weight ***and*** units (U.S. tons)	Maximum weight ***or*** units (U.S. tons)	68.8	17.2	8.6	5.5	0.0	128

Table 30. First-Year Mexican Driver Survey Results for Truck-Related Signs (continued)

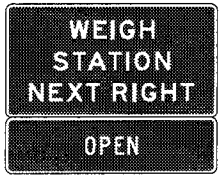
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	There is a weight limit on a bridge ahead	There is a weak bridge ahead	1.6	5.7	40.3	50.8	1.6	124
	If the answer indicates a "*BRIDGE AHEAD WITH A WEIGHT LIMIT*": a. What would you do if you saw this sign on the road?	Stop, turn around, or find another road if your truck weighs more than the limit	No acceptable response	16.7	N/A	58.3	16.7	8.3	12
	What does this sign mean?	Weigh station open ***and*** trucks must stop to be weighed	Weigh station open ***or*** trucks must stop to be weighed	29.8	3.2	25.8	39.5	1.6	124
	If "*BASCULA*" is not used as a response: a. What is a weigh station?	Place where trucks are weighed	No acceptable response	79.3	N/A	10.3	6.9	3.5	29
	For all responses: b. Does this sign require you to go through the weigh station?	Yes	No acceptable response	83.3	N/A	6.7	6.7	3.3	30

Table 30. First-Year Mexican Driver Survey Results for Truck-Related Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If response includes "*GRADE*" or "*SLOPE*": a. Does it go up or down?	Trucks ***and*** steep grade/downgrade	Trucks *or* steep grade/downgrade	64.2	22.5	10.8	2.5	0.0	120
	For all responses: b. What should you do when you see this sign?	Brake carefully, use brakes sparingly	No acceptable response	67.7	N/A	30.7	1.3	1.3	75
 Note: Green Circle	What does this sign mean?	Vehicles with hazardous cargo must follow sign or identifies a hazardous cargo route	No acceptable response	31.4	N/A	15.3	53.4	0.0	118
	For all correct responses: a. Give an example of a hazardous cargo	Record verbatim	N/A	65.0	N/A	5.0	20.0	10.0	20
 Note: Red Circle and Slash	What does this sign mean?	Vehicles with hazardous cargo are not allowed on this road or hazardous cargo prohibited or no hazardous cargo	Some type of prohibition	28.1	11.4	21.1	39.5	0.0	114

Table 31. First-Year Mexican Driver Survey Results for Pavement Markings

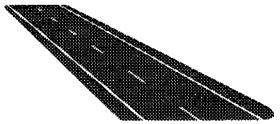
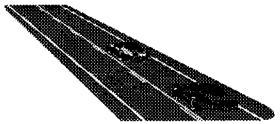
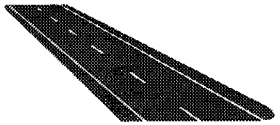
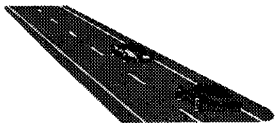
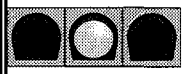
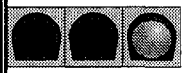
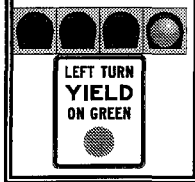
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
 Broken Yellow Centerline Pavement Marking	Is this a one-way road or a two-way road?	Two-way road or cars going in both/ opposing/different directions	No acceptable response	72.2	N/A	25.3	1.5	1.0	593
 Broken Yellow Centerline Pavement Marking	Is the blue car allowed to pass the red car?	Yes, if there is enough room to pass safely	Yes without identifying the safety element	36.8	38.0	22.8	0.5	1.9	589
 No Passing Zone Pavement Markings	Is the blue car allowed to pass the red car?	No	No acceptable response	.84.1	N/A	12.2	1.9	1.8	573
 Broken White Lane Line Pavement Marking	Is this a one-way road or a two-way road?	One-way or cars going in same direction	No acceptable response	51.5	N/A	45.2	2.6	0.8	505
 Broken White Lane Line Pavement Marking	Is the blue car allowed to pass the red car?	Yes	No acceptable response	81.8	N/A	14.3	1.4	2.4	490

Table 32. First-Year Mexican Driver Survey Results for Traffic Signal Indications and Left Turn Signal Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does the red in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Stop at intersection or do not cross intersection	No acceptable response	97.7	N/A	2.0	0.0	1.0	601
	What does the yellow in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Be prepared to stop, slow down, use caution, or red light coming up	No acceptable response	97.7	N/A	2.0	0.2	0.7	599
	What does the green in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Allowed to enter or cross the intersection, have the right-of-way	No acceptable response	97.6	N/A	0.7	0.2	1.5	596
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	No, the arrow tells me to go	I don't think so	80.8	0.0	17.6	0.5	1.2	587
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	No, the arrow/sign tells me to go	I don't think so	72.1	0.0	24.9	0.9	2.1	563
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	Yes, the green tells me I have to yield	Maybe/I think so	79.0	0.0	17.6	1.5	1.9	534
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	Yes, the green/sign tells me I have to yield	Maybe/I think so	78.2	0.0	17.2	2.6	2.0	499

Note: *Two different versions of this question were asked. "*What color is the signal for the traffic in the opposite direction?*" was asked approx. 10% of the time.

APPENDIX B

SECOND-YEAR SURVEY RESULTS

This appendix presents the devices, questions, response concepts, response rates, and sample sizes for the devices that were evaluated in the second-year survey. The tables in this appendix are essentially the same as the tables in Appendices A and B of the second-year report (2).

Table 33. Second-Year Texas Driver Survey Results for Regulatory Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If answer is only *STOP* a. What does this sign mean in Spanish? and/or b. What does *Stop* mean?	Must come to a complete halt (or stop or alto or pare)	No acceptable response	97.6	N/A	0.5	1.9	0.0	418
	What does this sign mean? If answer is only *YIELD* a. What does this sign mean in Spanish? and/or b. What does *Yield* mean?	Must give/cede/yield right-of-way (or cede el paso, de el paso) to traffic on the other roadway	No acceptable response	80.6	N/A	17.7	1.7	0.0	418
	What does this sign mean? For all responses: a. Is the speed in *kilometers per hour* or *miles per hour*?	Needs both concepts: maximum speed/ maximum velocity/speed limit ***and*** units (mph/miles)	Either concept: maximum speed/ maximum velocity/ speed limit ***or*** units (mph or miles)	95.3	4.0	0.4	0.4	0.0	277
	b. Why are there two different numbers?	One is day speed and the other is night (after dark) speed	No acceptable response	94.3	N/A	3.8	1.9	0.0	367
	What does this sign mean?	Must not enter the roadway from this direction, wrong way, or no entry	No acceptable responses	96.1	N/A	1.7	2.2	0.0	413
	What does this sign mean?	Right only or one way	No acceptable response	91.8	N/A	6.0	2.2	0.0	403

Table 33. Second-Year Texas Driver Results for Regulatory Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Stop for school bus loading, unloading or if bus lights are flashing	School bus	86.3	4.1	8.3	1.3	0.0	386
	For all responses: a. When do you have to stop for a school bus?	When the red lights are flashing or whenever the bus is loading or unloading	No acceptable response	94.8	N/A	4.1	1.1	0.0	267
	What does this sign mean?	Must wear safety/seat belt ***and*** it is state law	Wear safety/seat belt or just seat belt	54.3	36.0	1.0	8.7	0.0	414
	For truck drivers only: a. Does this sign apply to you?	Yes	No acceptable response	94.6	N/A	2.1	3.3	0.0	239

Table 34. Second-Year Texas Driver Survey Results for Warning Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Road curves/turns/bends ***and*** recommended speed is 35 mph (with units). Not speed limit or max. speed	Either road curves/turns/bends ***or*** recommended/ max. speed (or speed limit) is 35 mph	35.5	57.1	6.8	0.5	0.0	380
	If "*CURVE/TURN*" is not part of the response: a. What does the arrow mean?	Shows the change in road direction, direction you should drive	No acceptable response	48.5	N/A	50.0	1.5	0.0	130
	If "*SPEED*" is not part of the response: b. What does the "35" mean?	Recommended speed in mph (miles)	Speed limit or maximum speed	54.9	40.2	2.0	2.9	0.0	244
	Following any response that mentions "*SPEED*": c. Is this speed in *kilometers per hour* or *miles per hour*?	mph (miles)	No acceptable response	98.4	N/A	1.6	0.0	0.0	129
	What does this sign mean?	Two-way traffic or traffic going in both/opposing directions	No median between traffic	87.3	0.0	2.6	10.1	0.0	378
	What does this sign mean?	Railroad crossing ahead	Just railroad crossing or train	33.8	60.4	3.1	2.2	0.5	414
	What does this sign mean?	School crosswalk	Crosswalk or pedestrian crosswalk	53.9	36.3	8.8	0.5	0.5	386
	If the response does not include "*SCHOOL*": a. Who would you expect to see when you see this sign?	Students, or children, or school-age pedestrians	No acceptable response	77.7	N/A	21.3	0.0	1.0	206
	If the response does not include "*CROSSING*": b. Where would you expect to see them?	At or near the crosswalk	No acceptable response	26.1	N/A	27.5	46.4	0.0	153

Table 34. Second-Year Texas Driver Survey Results for Warning Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Any response that identifies construction, road work, or workers in or near the highway	Slow down without mention of road work	89.8	0.0	7.4	2.6	0.2	420
	For all responses: a. What should you do when you see this sign?	Watch for road or construction work and be prepared to slow down	Slow down	60.3	27.6	10.8	0.8	0.5	380
	For simple answers: b. Anything else?	Record verbatim	N/A	0.0	N/A	0.0	0.0	0.0	0.0
	Why are these two signs different? (i.e., *color*)	The orange sign indicates construction, ***and*** the yellow sign is a warning	Either the orange sign indicates construction, ***or*** the yellow sign is a warning	11.6	13.7	15.4	59.3	0.0	241
	For all responses: a. What do these signs mean?	Move to the left lane ***or*** right lane ends	No acceptable response	74.3	N/A	14.2	11.5	0.0	226

Table 35. Second-Year Texas Driver Survey Results for Pavement Markings

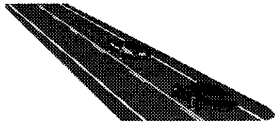
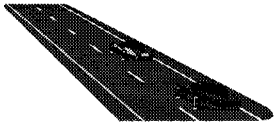
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
 Broken Yellow Centerline Pavement Marking	Is this a one-way road or a two-way road?	Two-way road or cars going in both/opposing/ different directions	No acceptable response	83.2	N/A	16.3	0.5	0.0	417
 Broken Yellow Centerline Pavement Marking	Is the blue car allowed to pass the red car?	Yes, if there is enough room to pass safely	Yes, without identifying the safety element	30.3	48.1	20.9	0.5	0.2	416
 No Passing Zone Pavement Markings	Is the blue car allowed to pass the red car?	No	No acceptable response	89.0	N/A	9.6	1.0	0.5	408
 Broken White Lane Line Pavement Marking	Is this a one-way road or a two-way road?	One way or cars going in same direction	No acceptable response	48.3	N/A	48.7	2.1	0.8	236
 Broken White Lane Line Pavement Marking	Is the blue car allowed to pass the red car?	Yes	No acceptable response	92.9	N/A	5.6	1.2	0.2	410

Table 36. Second-Year Texas Driver Survey Results for Traffic Signal Indications and Left Turn Signal Signs

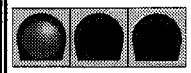
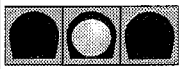
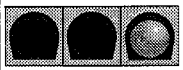
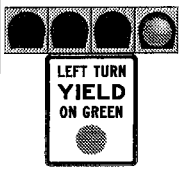
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does the red in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Stop at intersection or do not cross intersection	No acceptable response	99.5	N/A	0.2	0.0	0.2	417
	What does the yellow in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Be prepared to stop, slow down, use caution, or red light coming up	No acceptable response	98.8	N/A	1.2	0.0	0.0	417
	What does the green in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Allowed to enter or cross the intersection, have the right-of-way	No acceptable response	99.5	N/A	0.5	0.0	0.0	418
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?	No, the arrow tells me to go	I don't think so	85.9	0.0	4.1	9.2	0.7	412
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?	No, the arrow/sign tells me to go	I don't think so	94.6	0.0	4.9	0.2	0.2	406
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?	Yes, the green tells me I have to yield	Maybe/I think so	86.0	0.0	13.2	0.3	0.5	386
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?	Yes, the green/sign tells me I have to yield	Maybe/I think so	87.8	0.0	11.3	0.4	0.4	238

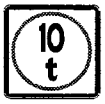
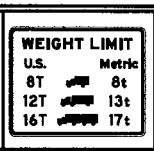
Table 37. Second-Year Texas Driver Survey Results for Spanish-Legend Alternative Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If answer is only *YIELD* a. What does this sign mean in Spanish? and/or b. What does *Yield* mean?	Must give/cede/yield right-of-way (or cede el paso, de el paso) to traffic on the other roadway	No acceptable response	85.2	N/A	7.0	7.9	0.0	229
	What does this sign mean? For all responses: a. Is the speed in *kilometers per hour* or *miles per hour*?	Needs both concepts: maximum speed/ maximum velocity/ speed limit ***and*** units (mph/miles)	Either concept: maximum speed / maximum velocity/ speed limit ***or*** units (mph or miles)	89.6	8.9	0.8	0.8	0.0	395
	b. Why are there two different numbers?	One is day speed and the other is night (after dark) speed	No acceptable response	96.9	N/A	1.5	1.5	0.0	325
	What does this sign mean?	Stop for school bus loading, unloading, or if bus lights are flashing	School bus	86.4	8.2	2.5	2.2	0.7	404
	For all responses: a. When do you have to stop for a school bus?	When the red lights are flashing or whenever the bus is loading or unloading	No acceptable response	92.6	N/A	6.4	0.6	0.3	326
	What does this sign mean?	Must wear safety/seat belt ***and*** it is state law	Wear safety/seat belt or just seat belt	54.3	25.9	14.0	4.5	1.2	243
	For truck drivers only: a. Does this sign apply to you?	Yes	No acceptable response	95.8	N/A	1.7	2.5	0.0	118
	What does this sign mean?	Must wear safety/seat belt ***and*** it is state law	Wear safety/seat belt or just seat belt	46.3	42.0	0.4	10.0	1.3	231
	For truck drivers only: a. Does this sign apply to you?	Yes	No acceptable response	93.2	N/A	5.1	1.7	0.0	237

Table 38. Second-Year Survey Results for Truck Speed Limit Signs

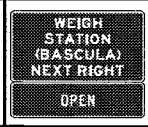
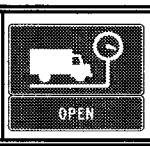
				**Questions and Correct Responses**
				#1: What does this sign mean?
				Correct
1.5	6.1	4.5	0.0	All criteria at first glance
				Partially Correct
98.5	100.0	98.5	100.0	Speed limit or maximum velocity
13.8	22.7	19.7	3.2	Applicable to trucks only
10.8	19.7	13.6	14.6	Units in miles per hour
40.0	16.7	31.8	50.0	One limit for day, other limit for night/dark
1.5	0.0	1.5	0.0	Incorrect
0.0	0.0	0.0	0.0	Not Sure
0.0	0.0	0.0	0.0	Unknown
				#2: What types of vehicles must obey this sign?
76.7	84.4	91.9	75.4	Trucks
				#3: Is the speed in kilometers or miles per hour?
96.6	94.9	98.4	94.4	Miles per hour
				#4: Why are there two different numbers?
79.7	81.7	90.0	87.7	Day and night/dark
				#5: Does this sign apply to you?
100.0	100.0	100.0	100.0	Yes/sure
65	66	66	62	Sample Size

Table 39. Second-Year Survey Results for Weight Limit Signs

				Questions* and Correct Responses
				#1: What does this sign mean?
				Correct
66.2	22.7	3.1	14.5	All criteria at first glance
				Partially Correct
78.5	22.7	3.1	50.0	Weight limit
69.2	22.7	7.7	0.0	10 tons (A4,B4,C4) or different trucks (D4)
4.6	22.7	24.6	24.2	Incorrect
13.8	54.5	67.7	25.8	Not Sure
0.0	0.0	0.0	0.0	Unknown
80.0	57.1	n/a	100.0	**#2: What types of vehicles must obey this sign?** Trucks
32.7	50.0	60.0		**#3: Are these U.S. or metric tons?** U.S. tons (A4) and metric tonnes (B4 and C4)
			62.1	**#3: What is the difference between the two columns shown?** One column for U.S. tons and one column for metric tonnes (D4)
66.7	80.0	50.0		**#4: How much is a ton?** 2000 lbs, 2200 lbs, 1000 kg, or 900 kg (A4, B4, and C4)
			27.8	**#4: How much is a U.S. ton?** 2000 lbs, 2200 lbs, 1000 kg, or 900 kg (A4, B4, and C4)
			61.1	**#5: How much is a metric tonne?** 1000 kg or 2200 lbs
65.4	84.6	75.0	32.1	**#6: Does the weight refer to entire weight or per axle?** Entire weight of truck
65	66	65	62	Sample Size

* Questions #2 through #6 asked only to drivers responding with *Correct* or *Partially Correct* response.

Table 40. Second-Year Survey Results for Weigh Station Signs

			Questions* and Correct Responses
			#1: What does this sign mean?
			Correct
12.1	33.3	14.2	Weigh station open AND trucks must stop to be weighed
			Partially Correct
24.2	65.2	28.3	Weigh station open OR trucks must stop to be weighed
9.1	0.0	19.7	Incorrect
54.5	1.5	37.8	Not Sure
0.0	0.0	0.0	Unknown
			#2: What is a weigh station?
100.0	100.0	100.0	Place where trucks are weighed
			#3: What vehicles must go through the weigh station?
96.7	83.7	83.3	Trucks
66	66	127	Sample Size

* Questions #2 and #3 asked only to drivers responding with *Correct* or *Partially Correct* response.

Table 41. Second-Year Survey Results for Low Clearance Signs

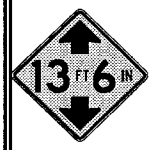
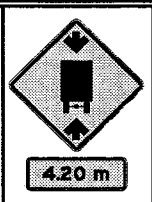
				Questions* and Correct Responses
				#1: What does this sign mean?
				Correct
9.2	21.2	18.5	9.7	All criteria at first glance
				Partially Correct
81.5	89.4	87.7	80.6	Bridge or structure, clear height
13.8	30.3	26.2	19.4	Height of "13, 6" (A3) or "4.20" (B3, C3, D3)
0.0	24.2	21.5	12.9	Units of feet and inches (A3), or meters (B3, C3, D3)
7.7	7.6	1.5	11.3	Incorrect
9.2	3.0	7.7	3.2	Not Sure
0.0	0.0	0.0	1.6	Unknown
				#2: What is the height shown in this sign?
67.9	98.1	76.8	100.0	13, 6 or 4.20
				#3: What are the units of measurement?
70.2	91.8	86.7	100.0	Feet, inches, or meters
65	66	65	62	Sample Size

Table 42. Second-Year Survey Results for Load Zone Bridge Signs

			Questions* and Correct Responses
			#1: What does this sign mean?
			Correct
12.3	87.4	70.8	Weight limit AND bridge
			Partially Correct
12.3	91.3	73.9	Weight limit
38.5	89.8	77.0	Bridge
23.1	5.5	13.8	Incorrect
38.5	0.8	6.2	Not Sure
0.0	0.0	0.0	Unknown
			#2: What would you do if you saw this sign on the road?
25.0	62.5	33.3	Look for posted weight limit and/or compare truck limit with posted limit
12.5	25.8	44.4	Stop, turn around, or find another road
65	127	65	Sample Size

* Question #2 asked only to drivers responding with *Correct* or *Partially Correct* response.

Table 43. Second-Year Survey Results for Hazardous Cargo Route Signs

			**Questions* and Correct Responses**
			#1: What does this sign mean?
12.3	3.0	29.9	*Correct* — Identifies hazardous cargo route
N/A	N/A	N/A	*Partially Correct* — No acceptable response
6.2	4.5	9.4	Incorrect
81.5	92.4	60.6	Not Sure
0.0	0.0	0.8	Unknown
			#2: What should you do if you see this sign on the road?
60.0	100.0	39.1	Follow this route if I am carrying hazardous cargo
65	66	127	Sample Size

* Question #2 asked only to drivers responding with *Correct* response.
Green circles on all signs. Four color diamond sign has red on top, blue on left, yellow on right, and white on bottom.

Table 44. Second-Year Survey Results for Hazardous Cargo Prohibited Signs

			**Questions* and Correct Responses**
			#1: What does this sign mean?
12.5	1.5	24.4	*Correct* — Vehicles with hazardous cargo are not allowed on this road, hazardous cargo prohibited, or no hazardous cargo
9.4	29.2	11.4	*Partially Correct* — Some type of prohibition
1.6	3.1	4.1	Incorrect
76.6	66.2	60.2	Not Sure
0.0	0.0	0.0	Unknown
			#2: What should you do if you see this sign on the road?
80.0	0.0	83.3	Do not follow this route if I am carrying hazardous cargo
64	65	123	Sample Size

* Question #2 asked only to drivers responding with *Correct* response.
Red circle and slash on all signs. Four color diamond sign has red on top, blue on left, yellow on right, and white on bottom.

APPENDIX C

THIRD-YEAR BORDER SURVEY RESULTS

This appendix presents the devices, questions, response concepts, response rates, and sample sizes for the devices that were evaluated at the border locations in the third-year survey. The tables in this appendix are essentially the same as the tables in Appendix A of the third-year report (3). The results presented in this appendix represent the entire border driver sample, which includes both Spanish- and English-speaking drivers. The summary tables in Chapter 2 and the descriptions in the third-year report separate the results into Spanish- and English-speaking drivers.

Table 45. 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	26.8	42.4	29.7	0.7	0.4	269
	Follow-up 1	19.3	67.7	N/A	10.8	0.0	2.2	269
	Follow-up 2	46.1	50.9	N/A	2.2	0.0	0.7	269
	Follow-up 3	50.6	42.4	N/A	5.6	1.5	0.0	269
	Primary	N/A	29.7	40.2	26.7	2.6	0.8	266
	Follow-up 1	30.5	55.6	N/A	11.3	0.0	2.6	266
	Follow-up 2	37.6	60.2	N/A	1.1	0.0	1.1	266
	Follow-up 3	48.1	43.2	N/A	6.4	0.8	1.5	266
	Primary	N/A	25.6	35.7	32.3	4.5	1.9	266
	Follow-up 1	27.8	59.8	N/A	9.8	0.0	2.6	266
	Follow-up 2	44.4	51.1	N/A	2.3	0.0	2.3	166
	Follow-up 3	51.1	41.4	N/A	6.0	0.0	1.5	266
	Primary	N/A	30.2	31.3	33.6	3.0	1.9	265
	Follow-up 1	31.3	60.0	N/A	4.5	0.0	4.2	265
	Follow-up 2	42.6	54.3	N/A	1.9	0.0	1.1	265
	Follow-up 3	50.9	45.7	N/A	1.9	0.4	1.1	265

Table 46. 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	8.7	68.1	5.1	13.0	5.1	254
	Follow-up	19.7	72.8	N/A	4.3	0.0	3.1	254
	Primary	N/A	9.8	78.3	2.0	7.1	2.8	254
	Follow-up	14.2	80.7	N/A	3.5	0.0	1.6	254
	Primary	N/A	6.3	82.7	1.6	6.7	2.7	255
	Follow-up	12.2	82.0	N/A	1.2	0.0	4.7	255
	Primary	N/A	8.6	80.1	3.9	5.5	2.0	256
	Follow-up	14.5	82.0	N/A	0.4	0.0	3.1	256

Table 47. 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	70.7	2.4	12.9	11.2	2.8	249
	Follow-up	22.9	58.2	N/A	16.5	0.0	2.4	249
	Primary	N/A	72.1	9.4	12.3	4.5	1.6	244
	Follow-up	15.6	64.3	N/A	16.0	0.0	4.1	244
	Primary	N/A	69.5	7.0	16.4	4.7	2.3	256
	Follow-up	17.2	60.5	N/A	18.0	0.0	4.3	256
	Primary	N/A	64.4	8.1	20.6	4.0	2.8	247
	Follow-up	20.2	56.3	N/A	20.2	0.0	3.2	247

Table 48. 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**
	Primary	N/A	1.3	18.4	47.4	27.6	5.3	76
	Follow-up	52.6	30.3	N/A	15.8	0.0	1.3	76
	Primary	N/A	1.3	26.6	59.5	7.6	5.1	79
	Follow-up	27.8	29.1	N/A	32.9	0.0	10.1	79
	Primary	N/A	2.6	35.5	51.3	3.9	6.6	76
	Follow-up	17.1	42.1	N/A	31.6	0.0	9.2	76
	Primary	N/A	6.5	37.7	51.9	0.0	3.9	77
	Follow-up	11.7	63.6	N/A	16.9	0.0	7.8	77

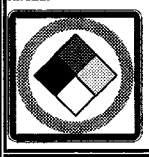
Table 49. Border Survey Results for Weight Limit Signs

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**
	Primary	N/A	37.0	35.8	18.5	3.7	3.7	81
	Follow-up	30.9	53.1	N/A	11.1	0.0	4.9	81
	Follow-up	25.9	50.6	N/A	19.8	1.2	2.5	81
	Follow-up	24.7	6.2	N/A	64.2	3.7	1.2	81
	Primary	N/A	41.8	50.6	6.3	0.0	1.3	79
	Follow-up	19.0	58.2	N/A	12.7	0.0	10.1	79
	Follow-up	5.1	58.2	N/A	31.6	2.5	2.5	79
	Follow-up	5.1	2.5	N/A	81.0	5.1	6.3	79
	Primary	N/A	52.6	35.5	9.2	0.0	2.6	76
	Follow-up	22.4	55.3	N/A	13.2	0.0	9.2	76
	Follow-up	5.3	57.9	N/A	27.6	3.9	5.3	76
	Follow-up	5.3	5.3	N/A	77.6	5.3	6.6	76
	Primary	N/A	62.3	27.3	3.9	2.6	3.9	77
	Follow-up	20.0	68.8	N/A	5.2	0.0	5.2	77
	Follow-up	6.5	64.9	N/A	18.2	3.9	6.5	77
	Follow-up	6.5	1.3	N/A	83.1	3.9	5.2	77

Table 50. Border Survey Results for Load Zoned Bridge Signs

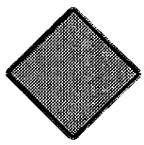
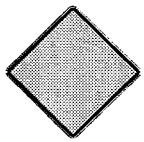
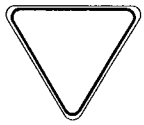
Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	Questions	Did Not Ask Question	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	Primary	N/A	3.8	21.8	34.6	34.6	5.1	78
	Follow-up	59.0	9.0	1.3	28.2	0.0	2.6	78
	Primary	N/A	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	N/A	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	N/A	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 51. 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 52. 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

APPENDIX D

THIRD-YEAR NON-BORDER SURVEY RESULTS

This appendix presents the devices, questions, response concepts, response rates, and sample sizes for the devices that were evaluated at the non-border locations in the third-year survey. The tables in this appendix are essentially the same as the tables in Appendix A of the third-year report (3).

Table 53. 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 54. 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 55. 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 56. 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**
	Primary	N/A	28.6	67.1	4.3	0.0	0.0	210
	Follow-up	0.0	88.1	N/a	10.5	0.0	1.4	210
	Follow-up	0.0	91.9	N/a	6.2	1.9	0.0	210
	Follow-up	This question was not asked.						

Table 57. Non-Border Survey Results for Load Zoned Bridge Signs

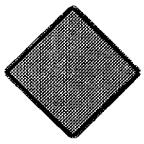
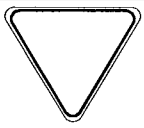
Primary Question		What does this sign mean?						
Follow-up Question		What would you do if you saw this sign in the road?						
Device	**Questions**	**Did Not Ask Question**	**Correct**	**Partially Correct**	**Incorrect**	**Not Sure**	**Unknown**	**Sample Size**
	Primary	N/A	38.7	50.9	7.5	1.9	0.9	106
	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 58. 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. Four color diamond sign has red on top, blue on left, yellow on right, and white on bottom.

Table 59. 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**
	Primary	19.8	66.8	12.0	1.4	217
	Primary	84.6	11.8	2.7	0.9	221

APPENDIX E

PROJECT STATEMENTS FOR FUTURE RESEARCH

Out of the 116 devices evaluated in this research project, the researchers identified two sign concepts that warrant evaluation as future research projects. This appendix presents partial TxDOT project statements that can serve as a starting point for initiating these future research efforts. These statements do not include some of the administrative information that is part of the standard project statement.

In addition to these concepts, the researchers also determined that the sign "Stop for School Bus When Red Lights Flashing" should be included in any future research project that evaluates driver understanding of traffic control devices.

Title: Assessment of Hazardous Cargo Signing
Estimated Duration (number of years): 2
Total Budget: $150,000-200,000
Description: The transport of hazardous materials on the Texas highway network presents many potential hazards of significant consequence. The issue is of particular concern in Texas because of the size of the petrochemical industry in the state. The Texas MUTCD contains two signs that are used to indicate roadways where hazardous materials are permitted and prohibited. However, there is little guidance on the use of these signs. Furthermore, previous research sponsored by TxDOT (Project 1274) found that a significant proportion of truck drivers did not understand the meaning of these signs. Comprehension levels were generally found to be well below 50 percent. Research is needed to evaluate the existing hazardous cargo signing in detail and develop alternatives with the potential for improving communication of hazardous material routing information. The research should also address the issues associated with selection of routes for vehicles with hazardous materials.
Implementation Plan: As of January 1, 1998, TxDOT is the designated state agency in charge of authorizing non-radioactive hazardous material routes in Texas. The results from this research will be incorporated into TxDOT practices, with the potential for modifications to policy and/or the Texas Administrative Code. The information obtained from this research will enable TxDOT to be more effective in fulfilling that responsibility. The results would also be incorporated into the Signs and Markings Volume of the Traffic Operations Manual.
Deliverables: Deliverables should include: 1) a research report describing the research activities and findings, 2) guidelines for identifying hazardous material routes, 3) guidelines for communicating hazardous material routing information to operators of vehicles with hazardous materials, and 4) recommendations for outreach activities related to vehicular transportation of hazardous materials. The guidelines should be prepared so that they can be incorporated directly into the Signs and Markings Volume of the Traffic Operations Manual.

Research Project Statement

Title: Evaluation of Regulatory, Warning, and Guide Signing Related to Vehicle Weight
Estimated Duration (number of years): 2
Total Budget: $150,000-200,000
Description: The Texas MUTCD contains at least 25 different signs that address weight-related aspects of heavy vehicles. These signs include at least 15 signs that inform drivers of different types of weight limits. The regulatory weight limit signs present weight limits that are a function of many different combinations of axles and axle weights. Many of these messages may be beyond the knowledge of the typical truck driver, who may only know the total weight of the vehicle. Furthermore, weigh stations typically weigh only the total weight of a vehicle. A recent TxDOT research project (1274) evaluated three of these signs (Weight Limit, Weigh Station, and Load Zoned Bridge) and found significant potential for improving the communication of weight-related messages to heavy vehicle operators. Research is needed to address the full spectrum of weight-related signing, including the effectiveness of existing signs, the potential improvement that could be achieved with new signs, the benefits of reducing the number of weight-related signs, the display of these signs, the relationship between weight-related signing and the permit process, and the relationship between signing and the highway infrastructure. Research activities should include development of alternatives, surveys of heavy vehicle operators, evaluations of the effectiveness of alternatives, and the development of recommendations.
Implementation Plan: The results of the research will be used to refine TxDOT practices for communicating weight restrictions and regulations. The research may lead to changes in the Texas MUTCD, the Signs and Markings Volume of the Traffic Operations Manual, or other TxDOT documents.
Deliverables: Deliverables should include: 1) a research report describing the research activities and findings, 2) guidelines for selection of weight limit signs, 3) guidelines for placement of weight limit signs, 4) guidelines for signing of weigh stations, and 5) guidelines for coordinating weight limit signing with the heavy vehicle permit process. Guidelines should be prepared so that they can be incorporated directly into the Signs and Markings Volume of the Traffic Operations Manual.