TTI: 0-1274

TEXAS TRANSPORTATION INSTITUTE

Assessment of Existing and Alternative Traffic Control Devices in Texas Border Areas

Research Report 1274-2

Cooperative Research Program

TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the
Federal Highway Administration and the
Texas Department of Transportation

1. Report No.		3. Recipient's Catalog No.
FHWA/TX-98/1274-2	PB98-164809	

4. Title and Subtitle	5. Report Date
ASSESSMENT OF EXISTING AND ALTERNATIVE TRAFFIC CONTROL DEVICES IN TEXAS BORDER AREAS	February 1998
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Dale L. Picha, H. Gene Hawkins, Ana K. Vizcarra, and Rachel A. Donovan	Research Report 1274-2

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	11. Contract or Grant No. Study No. 0-1274

12. Sponsoring Agency Name and Address		13. Type of Report and Period Covered
Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080	Project Director: Carlos Lopez, P.E. Traffic Operations Div. (512) 416-3330	Interim: September 1996 - August 1997
		14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.
Research Study Title: Traffic Control Devices for Drivers in Texas Border Areas

16. Abstract

This report describes the research activities during the second year of a three-year project conducted for the Texas Department of Transportation to identify, evaluate, and recommend traffic control devices in Texas border areas with Mexico. This second year, referred to as Phase II, included evaluations of 30 different traffic control devices by 546 passenger car drivers in three border-area cities, and evaluations of 26 different truck-related traffic signs and alternatives by 260 truck drivers in Laredo, Texas. The results indicated that many of the drivers in the border area have adequate understanding of most basic traffic control devices. Areas of improvement, especially for an educational effort, include construction and maintenance work zone devices, pavement markings, and a select few English-legend signs and truck-related signs with U.S. Customary units. Recommendations are made for follow-up evaluations of passenger car and truck drivers for selected regulatory, warning, and guide signs.

17. Key Words	18. Distribution Statement
Traffic Control Devices, Signing, Bilingual Signs, Driver Comprehension, MUTCD	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	88	

ASSESSMENT OF EXISTING AND ALTERNATIVE TRAFFIC CONTROL DEVICES IN TEXAS BORDER AREAS

by

Dale L. Picha
Assistant Research Scientist
Texas Transportation Institute

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

Ana K. Vizcarra
Graduate Research Assistant
Texas Transportation Institute

and

Rachel A. Donovan
Graduate Research Assistant
Texas Transportation Institute

Research Report 1274-2
Research Study Number 0-1274
Research Study Title: Traffic Control Devices for Drivers in Texas Border Areas

Sponsored by
Texas Department of Transportation
In Cooperation with
U.S. Department of Transportation
Federal Highway Administration

February 1998

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

IMPLEMENTATION RECOMMENDATIONS

The results of this project led to the following guidelines for implementation to improve safety and driver understanding of traffic control devices in Texas border areas:

1) Results and recommendations for the use of Spanish-word legends in certain traffic signs used in the Texas/Mexico border area;

2) Results and recommendations for educational efforts for specific traffic control devices targeted at border-area drivers; and

3) Recommendations for continual research efforts during the third and final year of Project 1274 on traffic control devices in the border area.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. This project was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 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, and is NOT INTENDED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES. The engineer in charge of the project was H. Gene Hawkins, Jr., P.E. #61509.

ACKNOWLEDGMENT

The research reported herein was performed by the Texas Transportation Institute as part of a study entitled "Traffic Control Devices for Drivers in Texas Border Areas," sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Mr. Carlos Lopez, P.E., of the Texas Department of Transportation Traffic Operations Division, served as the research project director (P.D.).

The authors wish to acknowledge several members of the Project Advisory Panel who provided technical assistance for the contents report and throughout the project contract.

Project Director

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

Project Advisory Panel

- Ms. Terry Carson, San Antonio District, Texas Department of Transportation;
- Mr. Ted Ozuna, San Antonio District, Texas Department of Transportation;
- Ms. Jeanie Swanson, Traffic Operations Division, Texas Department of Transportation;
- Mr. Carlos Chavez, El Paso District, Texas Department of Transportation;
- Mr. Jesus Leal, Pharr District, Texas Department of Transportation;
- Mr. Bret Mann, University of Texas Pan American (UTPA); and
- Mr. Lewis Rhodes, Safer Rhodes, Inc.

The authors also wish to acknowledge several individuals who assisted with managing personnel and administering surveys in the Texas/Mexico border area, including Mr. Bret Mann and his staff at UTPA and Mr. Alberto Castano-Pardo, Ms. Christina Borja-Slabic, and Mr. Ricardo Morales of the Texas Transportation Institute.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

Most citizens of the United States who drive on U.S. highways are familiar with the U.S. system of traffic signs, signals, and pavement markings, collectively known as traffic control devices. The meaning of these standard devices, however, may not be as obvious to a motorist visiting from another country. Without the ability to understand the basic traffic control devices that exist in a foreign country, a driver's ease of mobility and safety may be impaired. Comprehension is vital to the effectiveness of traffic control devices, which "provide for the orderly and predictable movement of all traffic . . . throughout the national highway transportation system, and provide such guidance and warnings as are needed to insure the safe and uniform operation of individual elements of the traffic stream" *(1)*.

In the areas of Texas along the border with Mexico, special consideration must be given to the difficulties encountered by people driving on a highway system in a foreign country. The highways in Texas border areas experience large volumes of traffic comprised of Mexican tourists and truck drivers who speak only Spanish or very limited English. In addition, many Texas residents living in these border areas have limited understanding of the English language. Due to the special characteristics of the driving population in Texas border areas, the effectiveness of the standard U.S. traffic control devices must be evaluated to determine how well the current devices meet the needs of border-area drivers.

PROJECT BACKGROUND

The ability to provide drivers with traffic control devices that are easy to see and understand is important for the safe and efficient operation of a transportation system. Unfortunately, ensuring that an increasingly diverse population of drivers on a given roadway understand the traffic control devices is not a simple task. This task becomes even more challenging in areas of Texas near the international border between the U.S. and Mexico. Many of the Mexican drivers may not understand written English very well and may not be familiar with the standard traffic control devices used in Texas, many of which are text-based signs.

The expected increases in international traffic due to the opening of the Texas-Mexico border as a result of the North American Free Trade Agreement (NAFTA) will have a significant impact on the border region. An increase in trade implies that there will be an increase in traffic volume, which will bring all types of vehicles and drivers onto the U.S. highway system in this region. The increase in traffic has prompted transportation officials to investigate levels of driver comprehension of traffic control devices in the Texas/Mexico border area *(2)*.

Some of the issues that are believed to affect driver comprehension of traffic control devices in Texas/Mexico border areas are the following *(2)*:

- The use of two languages, English and Spanish, throughout the border area;
- The presence of two systems of measurement (International System (S.I.) in Mexico and United States (U.S.) Customary in Texas);
- Actual differences in the traffic control devices used in Mexico and Texas; and
- Cultural differences between U.S. and Mexican drivers.

Furthermore, Texas is the primary gateway for U.S.-Mexico traffic and trade. In 1994, the truck shipments entering and leaving Texas accounted for 69 percent of all truck shipments made across the entire U.S.-Mexico border *(3)*. Over 2.5 million truck shipments valued at nearly 50 billion dollars passed over international bridges in Texas in 1994. In that same year, 88 percent of the total dollar amount of trade crossing the Texas border was made by truck *(3)*. When NAFTA is fully implemented, the amount of international truck traffic throughout the border states is expected to increase dramatically. Since Texas is the major gateway for international traffic and trade from Mexico, the state must find ways to minimize the negative effects of the increased presence of traffic in the border areas *(3)*. An issue of great concern is the adequacy of the U.S. standard signs for understanding by international drivers, especially truck drivers, in this region.

Project 1274 Goals

The Texas Department of Transportation (TxDOT) sponsored Project 1274, a three-year research project to evaluate and improve the comprehension of traffic control devices in Texas border areas. The goals of the project are: 1) to identify the information needs of drivers in Texas border areas; 2) to determine how traffic control devices can be improved to better convey the needed information to border-area drivers; and 3) to develop recommendations for the use of the improved devices.

Project 1274 Objectives

The researchers established a three-phase work plan and multiple objectives to meet the project goals. The research phases include the following:

- Phase I — Identify driver information needs and deficiencies;
- Phase II — Evaluate existing and proposed traffic control devices; and
- Phase III — Develop and implement research recommendations.

The researchers further expanded these phases and established the following objectives:

- Identify existing concerns and difficulties in meeting the information needs of border-area drivers;
- Identify available information on the use of traffic control devices in areas throughout the United States with special information needs;
- Contact organizations and individuals who may have knowledge or concerns associated with the focus of the research project;
- Identify the pertinent characteristics of drivers, vehicles, and roadways that may affect the use of traffic control devices in Texas border areas;

- Identify and assess any special issues that may impact the manner that traffic control devices are used in border areas;
- Assess the effectiveness of existing traffic control devices in meeting the information needs of border-area drivers;
- Develop strategies for improving traffic control devices in border areas;
- Evaluate the potential effectiveness of improvement strategies;
- Develop recommendations for improving and using traffic control devices in Texas border areas;
- Assess impacts of recommendations and solicit input from affected organizations;
- Develop a document intended specifically for implementing the research project recommendations within TxDOT; and
- Document the research project activities in interim and final reports.

The first-year research objectives, or Phase I objectives, were to identify concerns and difficulties in meeting the information needs of border-area drivers and identify pertinent characteristics of drivers, vehicles, and roadways that may affect the use of traffic control devices in Texas border areas. From telephone interviews, comprehension surveys of drivers from Mexico, and a review of pertinent literature, it was determined that Mexican drivers do understand most of the traffic control devices evaluated, with a few exceptions noted in the first-year report *(2)*.

PHASE II OBJECTIVES

This report addresses the second-year, or Phase II, research activities of TxDOT Project 1274 that were conducted to evaluate the comprehension of existing and alternative traffic control devices among a sample of Texas drivers in the border area and a sample of truck drivers entering the U.S. from Mexico. During the second-year research, the following objectives were established:

- Assess driver comprehension of existing and alternative traffic signs, signals, and markings in the border area among a sample of drivers with Texas license plates;
- Compare Texas driver comprehension of traffic control devices with the Mexican driver results from the Phase I evaluations;
- Assess driver comprehension of existing and alternative traffic signs in the border area among a sample of truck drivers entering the U.S. from Mexico; and
- Develop recommendations for the design and use of traffic control devices based on research assessments.

The researchers first assessed the comprehension of existing U.S. traffic control devices among a sample of drivers with Texas license plates in the Texas/Mexico border area. With this assessment, the researchers also evaluated a few select Spanish-language traffic sign alternatives. This assessment was a follow-up to the research conducted during the first-year of the study in which drivers with Mexican license plates were surveyed to determine how well they understood U.S. traffic control devices.

Secondly, the researchers assessed the comprehension of U.S. truck-related traffic signs and alternatives developed for each among a sample of commercial truck drivers in the Texas/Mexico border area. For the safe and efficient use of roadways, it is important that truck drivers understand the traffic control devices that make reference to limits on height, weight, speed, and permissible cargo allowed for trucks. Truck-related traffic signs that address these topics were selected as "critical" traffic control devices. A set of alternatives were developed for the critical truck-related traffic signs, and these alternatives were tested against the standard devices.

Researchers used the results of both evaluations to develop recommendations to improve comprehension of traffic signs in Texas border areas.

RESEARCH METHODOLOGY

During the second-year study period, researchers completed eight major research tasks to meet the project objectives. The tasks included:

1) Select devices and develop Spanish-language alternatives for a Texas driver survey;
2) Develop and administer Texas driver survey of traffic control devices;
3) Analyze comprehension data and compare to first-year results of Mexican driver comprehension of traffic control devices;
4) Select devices and develop alternatives for truck driver survey;
5) Develop and administer truck driver survey;
6) Analyze comprehension data;
7) Develop recommendations based on survey assessments and results; and
8) Document research results in second-year report.

FINDINGS AND RECOMMENDATIONS

Researchers used the results of the project evaluations to develop recommendations for improving driver understanding of traffic control devices in Texas border areas. The recommendations provide future implementation guidelines for Phase III of Project 1274. Chapters 3 and 4 summarize the results of the survey evaluations and the Phase II recommendations.

CHAPTER 2
STUDY METHODOLOGY

The primary tasks of the second-year, or Phase II, research activities were two driver comprehension surveys, one administered to drivers in vehicles with Texas plates, and one administered to truck drivers, both of whom were entering the U.S. from Mexico. The survey of drivers with Texas license plates, herein referred to as the Texas driver survey, was intended to evaluate select traffic control devices (including regulatory, warning, and guide signs; traffic signals; construction and maintenance work zone devices; and pavement marking indications) and to provide a basis of comparison for the first-year data. The survey of truck drivers entering the U.S., herein referred to as the truck driver survey, was intended to evaluate the comprehension of standard and alternative truck-related traffic signs, including devices related to height, weight, speed, and route restrictions.

This chapter describes the research activities associated with both of the Phase II surveys. For clarification in this report, the following terms are defined:

- **Texas Driver**: A motorist driving a vehicle with a Texas license plate;
- **Mexican Driver**: A motorist driving a vehicle with a Mexican license plate; and
- **Truck Driver**: As it relates to Phase II of Project 1274, an operator of a commercial cargo truck entering the U.S. from Mexico.

TEXAS DRIVER SURVEY

The Texas driver survey was administered to Texas drivers in Laredo, Texas at the Gateway to the Americas Bridge (Bridge #1) and at the Juarez-Lincoln Bridge (Bridge #2); in Hidalgo, Texas at the Hidalgo-Reynosa Bridge; and in Pharr, Texas at the Pharr-Reynosa Bridge. All surveys were administered in April 1997. The surveys were administered to a total of 546 Texas drivers, with each driver answering an average of 26 questions.

Identification and Selection of Traffic Control Devices

The researchers selected and evaluated a total of 30 different traffic control devices or device scenarios in the Texas driver survey. The following list provides a summary of those devices:

- 7 regulatory signs;
- 6 warning signs;
- 5 pavement marking scenarios; and
- 7 signal displays.

Regulatory Signs. Five of the seven regulatory signs chosen for evaluation represented some of the more basic traffic signs used on the roadway today. These included the STOP sign (R1-1), the YIELD sign (R1-2), and Speed Limit sign (R2-1) with the supplemental Night sign (R2-3), the Do Not Enter sign (R5-1), and the One Way sign (R6-1). Researchers also chose two other signs, the STOP FOR SCHOOL BUS LOADING AND UNLOADING sign (R19-1) and the FASTEN SAFETY BELTS STATE LAW sign (R19-8), because of their critical safety message for all drivers. Figure 1 illustrates these seven devices.

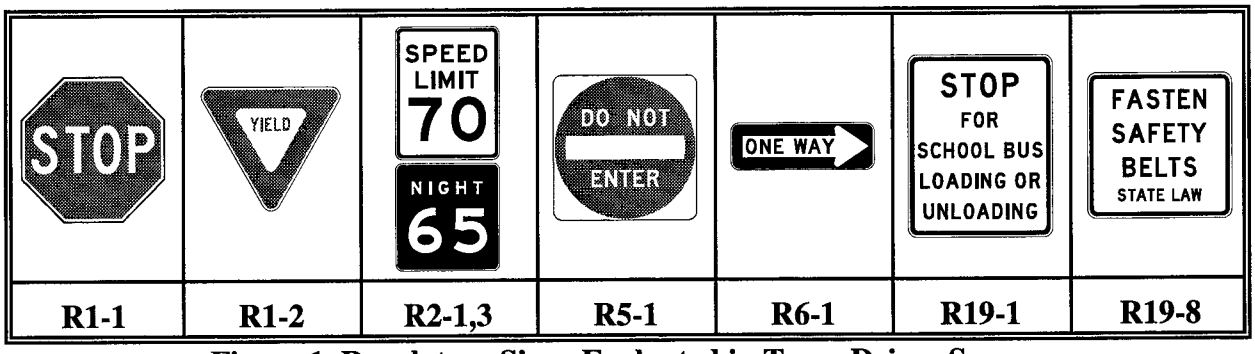


Figure 1 Regulatory Signs Evaluated in Texas Driver Survey

Warning Signs. The researchers selected six different warning signs, evaluated also during the Phase I research, to evaluate in the Phase II Texas driver survey. Four standard warning signs, including the Curve sign (W1-2R) with the 35 M.P.H. sign supplement (W13-1), the Two Way Traffic sign (W6-3), the Railroad Advance Warning sign (W10-1), and the School Advance sign (S1-1) were found in previous studies by the Texas Transportation Institute (TTI) to present comprehension difficulties for selected samples of Texas and Mexican drivers (*2*, *4*). The researchers also chose two construction-related traffic signs to evaluate in the Texas driver survey for their color and legend meaning. These orange-colored, construction-related signs included the RIGHT LANE ENDS sign (CW9-1R) and the ROAD WORK AHEAD sign (CW21-4D). Figure 2 illustrates all six devices.

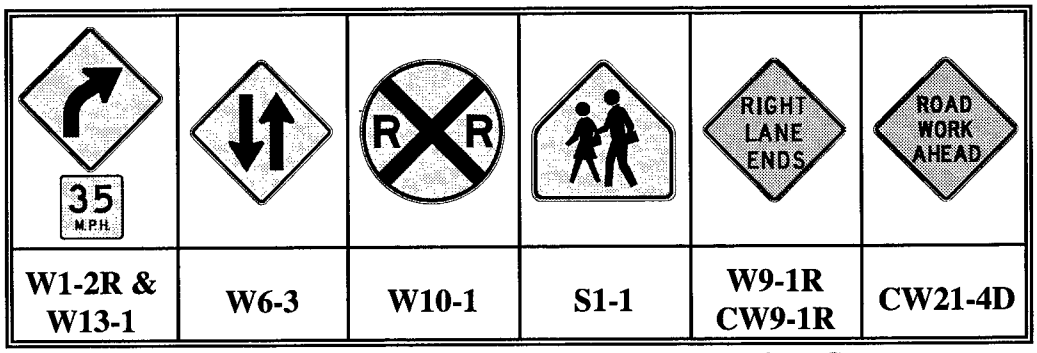


Figure 2 Warning Signs Evaluated in Texas Driver Survey

Pavement Markings. In the Phase I evaluation, researchers evaluated Mexican driver comprehension of five different U.S. pavement marking scenarios, illustrated in Figure 3 below (*2*). These five scenarios were originally chosen for evaluation in Phase I based on their relatively poor comprehension performance among border-area drivers in previous TTI research (*5*). The same five scenarios were again evaluated in the Phase II Texas driver survey.

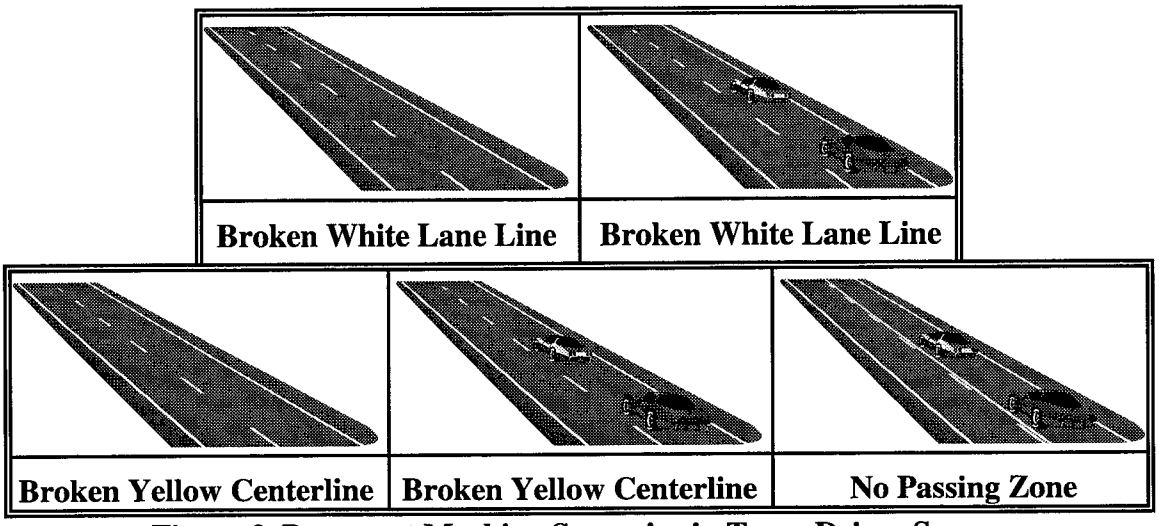


Figure 3 Pavement Marking Scenarios in Texas Driver Survey

Signal Displays. As with the pavement marking scenarios, Phase I and Phase II driver surveys evaluated several signal displays. In the Phase I survey of Mexican drivers, researchers chose three basic signal displays for evaluation, primarily to provide a baseline for comparing comprehension with other traffic control devices. Researchers considered the red, yellow, and green ball indications, shown in Figure 4, to be *basic* signal displays that drivers in the U.S. as well as Mexico should understand, since all three displays have the same intended meaning in both countries. The researchers again chose these three displays for evaluation in Phase II.

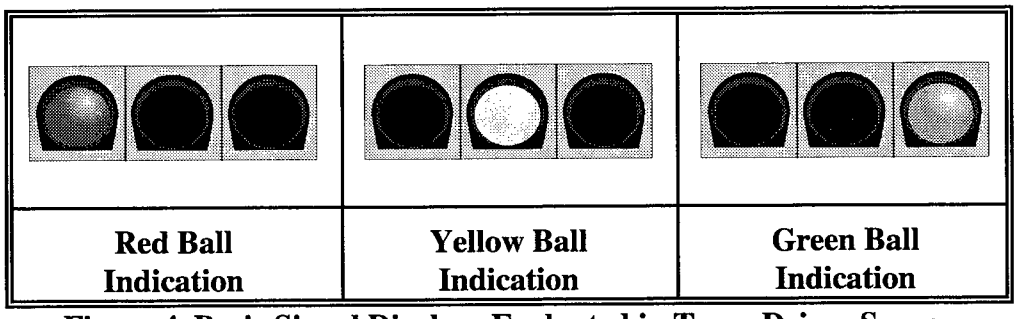


Figure 4 Basic Signal Displays Evaluated in Texas Driver Survey

The researchers also evaluated four different signal and sign displays related to protected and permissive left turns. These four devices, illustrated in Figure 5, were evaluated in the Phase I survey of Mexican drivers. The researchers originally chose these signal and sign displays due to limited data available on driver comprehension of protected/permissive left turns. The displays were also chosen due to the concern of the research staff over the potential for limited driver comprehension in the Texas/Mexico border area. No such signal display standards (i.e., green arrow or green ball displays) exist in Mexico and, therefore, could present significant comprehension difficulties for Mexican drivers entering the U.S. The four displays presented in Figure 5 were again evaluated in the Phase II survey of Texas drivers.

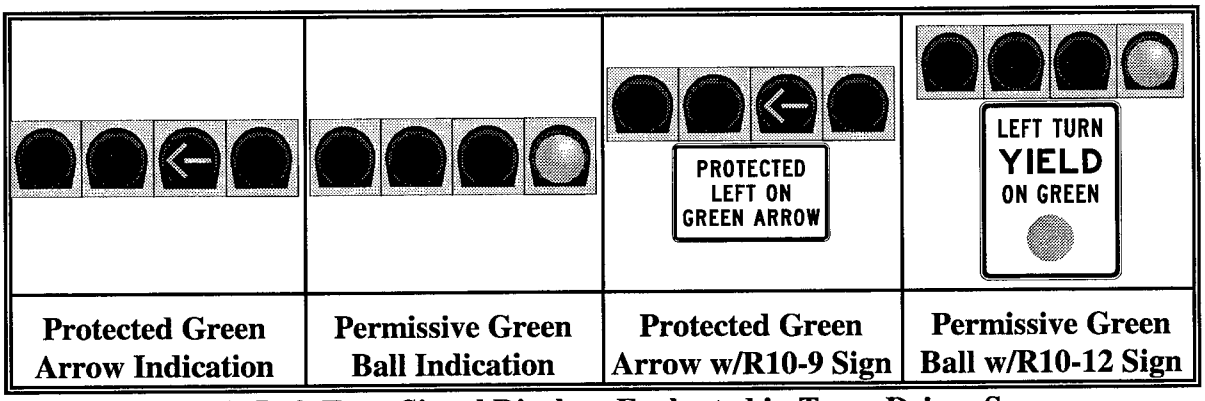


Figure 5 Left Turn Signal Displays Evaluated in Texas Driver Survey

Development of Spanish-Language Alternative Devices

The research team included several Spanish-language alternative traffic control devices in the survey to collect additional information on the performance of these types of signs. Figure 6 illustrates these devices, all regulatory signs. These signs were selected due to their low comprehension levels in the Phase I surveys of Mexican drivers.

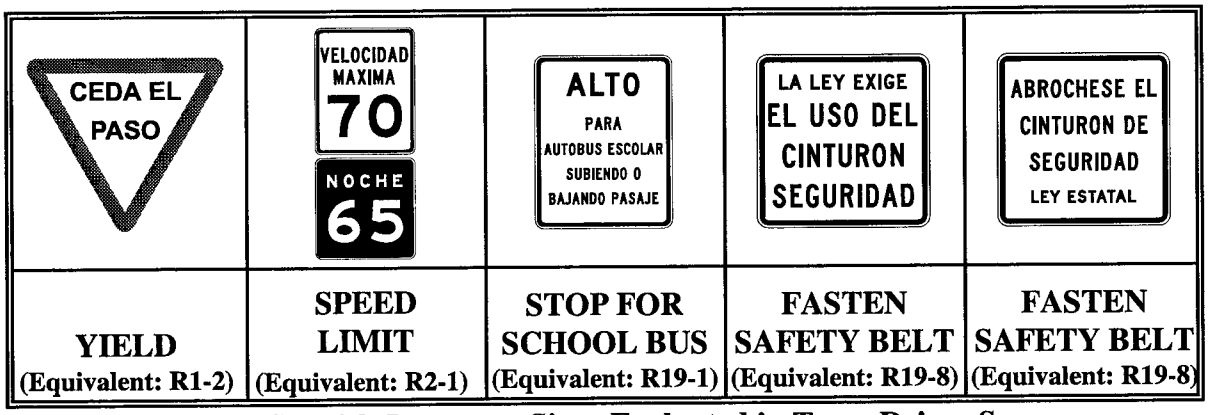


Figure 6 Spanish-Language Signs Evaluated in Texas Driver Survey

YIELD Sign Alternative. The Mexican equivalent to the U.S. YIELD sign (R2-1) was chosen for evaluation in this study because of its similarities in shape and color with the U.S. sign, because of its widespread use in Mexico, and for its potential for use in Texas (in the border area) as an alternative for improving driver comprehension of its intended meaning. The Spanish legend, CEDA EL PASO, translates to "cede" or "give way" to the "path," similar to the intended meaning of the U.S. YIELD sign.

The Mexican government manual on traffic control devices, *Manual de Dispositivos Para el Control del Tránsito en Calles y Carreteras*, contains the Mexican CEDA EL PASO sign (*6*). In Section SR-2.1.2, the manual indicates that the CEDA EL PASO sign "will be an equilateral triangle, with a downward vertex," similar to the shape of the U.S. YIELD sign. With respect to color, Section SR-5 indicates that the sign will have a white background . . . , a red perimeter band and black letters." The use, designated in Section SR-7, "should always be determined through a study of local traffic conditions" and should not be considered as a substitute of the ALTO (STOP) sign" (*6*).

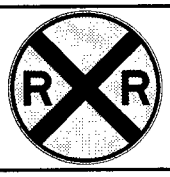
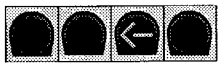
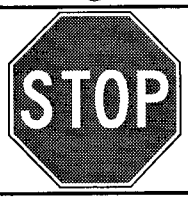
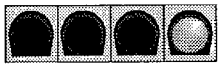
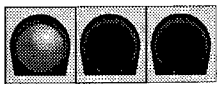
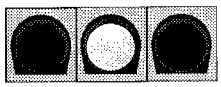
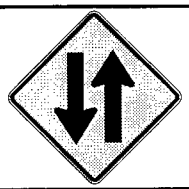
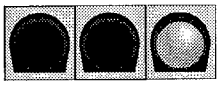
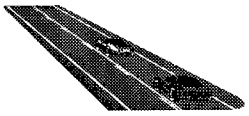
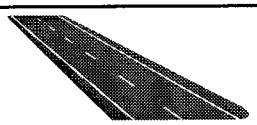
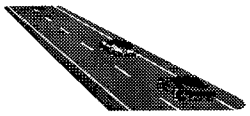
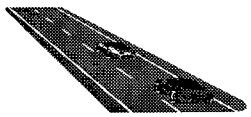
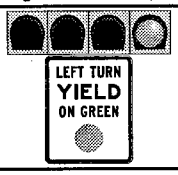
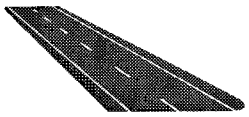
Other Spanish-Language Alternatives. The four remaining Spanish-language alternatives in Figure 6 were developed based on the need to evaluate three critical safety-related traffic signs. The day/night Speed Limit sign (R2-1 and R2-3), the STOP FOR SCHOOL BUS LOADING AND UNLOADING sign (R19-1), and the FASTEN SAFETY BELTS STATE LAW sign (R19-8) were chosen for their intended safety messages related to vehicle speed, school bus safety and awareness, and the state law regarding seat belt usage, respectively. The alternatives were developed by directly translating the English legend to a Spanish equivalent legend. Researchers encountered some difficulty in the direct translation of the FASTEN SAFETY BELT STATE LAW sign and thus developed two different versions in Spanish for this sign.

Survey Instrument Format

Similar to the first-year driver surveys (*2*), the survey instrument was in a flash-card format, with an enlarged image of a traffic control device on one side of a card and one or more comprehension-related questions on the opposite side. A survey administrator presented the image to the driver as he/she read the question on the opposite side. All participants' responses were audio recorded on micro-cassette recorders for future playback, data reduction, and analysis.

The survey was divided into three separate sets, with each set containing approximately 10 different traffic control devices. The devices were arranged according to the order of Sets A, B, and C, as presented in Table 1. Each administrator initially began the survey with Question 1 in Set A and proceeded through all sets and asked as many questions as possible to each participant. For the Spanish-language alternative in Question 9 of Set A, of the four survey administrators, two asked questions that pertained to one device, while the other two administrators asked questions that pertained to the other device. Each survey participant only saw one version of this sign.

Table 1 Organization of Texas Driver Survey

Question	Set A	Set B	Set C
1			
2			
3			
4			
5			
6			
7			
8			
9			
10	no sign		

Survey Administration

As stated previously, the Texas driver survey was administered at international bridge crossings in Laredo, Hidalgo, and Pharr, Texas. The survey was administered to drivers in vehicles with Texas license plates. The drivers were questioned while waiting in queues to enter the U.S. Customs Service and U.S. Immigration inspection stations on the north end of the international bridges in these three cities.

Four researchers were present at each survey site to administer the survey instrument. Each administrator approached a candidate vehicle with Texas license plates, introduced themselves, explained their intent with the survey, and asked each driver if they were interested in participating "while they waited in line" to be processed/approved by U.S. Customs or U.S. Immigration. When the driver gave verbal permission, each administrator asked as many survey questions as possible, but the number of questions asked per participant varied depending upon the driver's delay in the queue. If the administrator was able to complete the entire survey, he/she proceeded to the next candidate vehicle.

Researchers administered the survey over a three-day period in each city on Friday, Saturday, and Sunday of the week, which, according to U.S. Customs, were the peak travel days during the week. The peak travel times during the day, which were optimal for administering surveys, occurred on Friday from 7 a.m. to 9 a.m. and from 4 p.m. to 6 p.m., and during daylight hours on the weekend.

TRUCK DRIVER SURVEY

The Phase II truck driver survey was administered to Mexican truck drivers in Laredo, Texas at the Laredo/Colombia Solidarity Bridge in July 1997. The surveys were administered to a total of 260 truck drivers over a three day period, with each driver answering nine questions related to the comprehension of truck-related traffic signs.

Identification and Selection of Traffic Control Devices

The researchers selected nine MUTCD-conforming, U.S. truck-related traffic signs to evaluate in this survey, many of which were evaluated in Phase I. The signs related to truck height, weight, speed, or route designation. For seven of these nine signs, the researchers developed two or three alternative designs. The remaining two signs included an all Spanish-legend sign to indirectly test each truck driver for literacy and a truck and hazardous cargo route sign, a sign that was developed by the TxDOT Laredo District. Researchers evaluated a total of 26 different signs, including standard and alternative designs, in the truck driver survey.

The truck-related signs evaluated in this research were selected based on the level of misunderstanding of the signs as determined by the first-year research (2) and the perceived importance of the signs in Texas border areas as determined by the researchers and the TxDOT Project Advisors. The nine signs chosen for the survey (and for alternative sign development) included:

- Truck Speed Limit sign (with Night supplemental sign) (R2-2a and R2-3);
- WEIGHT LIMIT 10 TONS sign (R12-1);
- Hazardous Cargo Route sign (R14-2);
- Hazardous Cargo Prohibition sign (R14-3);
- Clearance sign (W12-2T);
- LOAD ZONED BRIDGE sign (W12-5);
- Weigh Station Exit Direction sign (D8-2);
- An all-Spanish legend sign to indirectly test for literacy; and
- A truck and hazardous cargo route sign.

Development of Truck-Related Alternative Devices

Four different sets of traffic sign alternatives were developed for the truck driver survey. The first set, or Set A, consisted primarily of the seven standard signs mentioned above. The remaining sets (Sets B, C, and D) contained alternative signs that were developed and tested against the standard signs in Set A. All four sets included the Spanish-language sign (to test for literacy) and the truck and hazardous cargo route sign.

Truck Speed Limit Signing. During the first-year survey, the Truck Speed Limit sign (R2-2a and R2-3) exhibited a high correct response rate for the understanding of the concepts of posted speed limit and units (miles per hour) (2). The alternatives developed for the Phase II truck survey, shown in Figure 7, focused on increasing comprehension of the concept that the speed limit is for trucks only and the reason for the two posted speed limits (one for day, one for night). The U.S. standard signs (R2-2a and R2-3) were evaluated in Set A. For the alternative in Set B, a plaque with the Spanish word *Camion* (meaning "truck") was placed above the standard Truck Speed Limit sign. The alternative in Set C made use of a plaque bearing the symbol for a semi-trailer truck (adapted from the Weight Limit symbol sign, R12-5) placed above the standard sign. The alternative in Set D replaced the English text of the standard sign with a Spanish translation (*Camion Velocidad Maxima* with *Noche* supplemental sign).

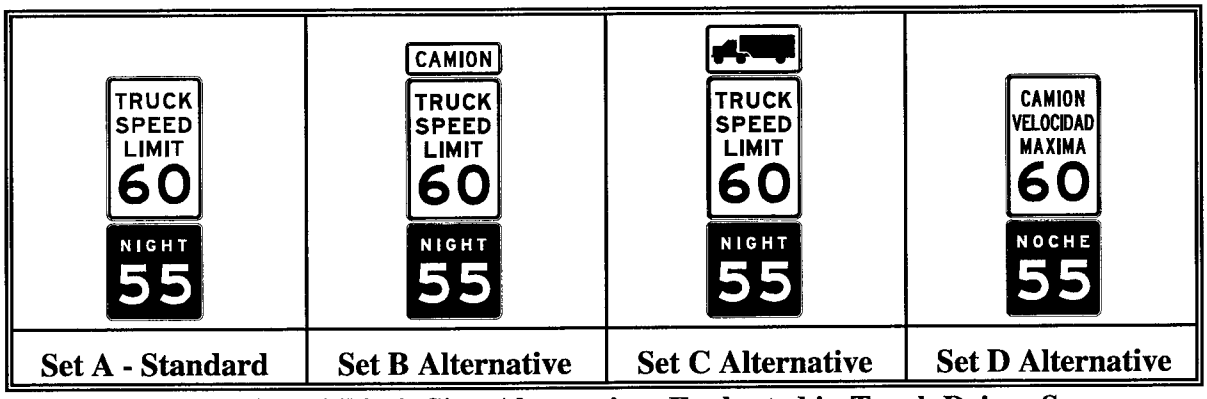


Figure 7 Speed Limit Sign Alternatives Evaluated in Truck Driver Survey

Hazardous Cargo Signing. Researchers evaluated three alternatives for each of the Hazardous Cargo Route signs (R14-2 and R14-3), as illustrated in Figure 8. The standard Hazardous Cargo Route sign (R14-2) and the Hazardous Cargo Prohibition sign (R14-3) were part of Set A. The alternative in Set B had a black "diamond" shape in place of the letters "HC" found in the standard sign. The black "diamond" alternative is the Canadian symbol for hazardous cargo routing (*7*). For Sets C and D, the researchers replaced the standard "HC" in each of the standard Hazardous Cargo signs with a symbol developed by the National Fire Protection Association (NFPA) and used to indicate health, flammability, and reactivity hazards of chemicals. The symbol is a four-colored "diamond." A number rating system is also used with each color to distinguish between the relative fire, exposure, and control hazards of different types of chemicals. This NFPA symbol was developed primarily for fire protection and emergency personnel as a system of easily identifying and understanding the hazards associated with various materials. Figure 9 illustrates the color and number system of this NFPA symbol.

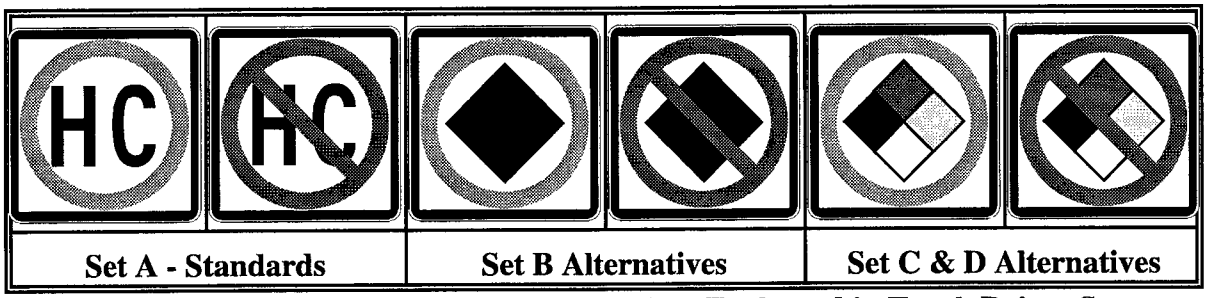


Figure 8 Hazardous Cargo Sign Alternatives Evaluated in Truck Driver Survey

Vertical Clearance Signing. The standard Clearance sign (W12-2T) was thought to present problems for Mexican truck drivers due to the U.S. Customary units used to designate the height of a bridge or structure. To improve understanding of the height expressed by the Clearance sign, three additional alternatives were developed for the survey and are illustrated in Figure 10. The standard sign (W12-2T) appeared in Set A. The alternative in Set C replaced the legend reading "13 ft 6 in." in the standard sign with the equivalent metric legend reading "4.2 m" (to indicate 4.2 meters). This was in accordance with the American Association of State Highway Transportation Officials (AASHTO) plan for the implementation of metric signing in the U.S., which will require heights in meters to be displayed to the nearest tenth of a meter. Since many people in Mexico are accustomed to thinking in terms of meters and centimeters, rather than meters and decimeters, there was a concern that some drivers would misinterpret the "4.2 m" to mean 4 meters, 2 centimeters, rather than 4 meters, 2 decimeters (or 20 centimeters). To address this concern, the alternative in Set B had a legend of "4.20 m." The alternative in Set D was similar to the Mexican standard sign for vertical clearance (*6*), which includes a plaque reading "4.20 m."

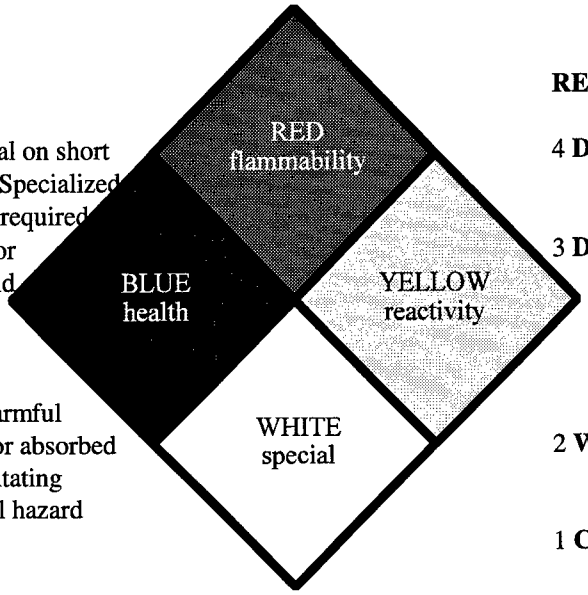
NFPA CHEMICAL HAZARD LABEL

FLAMMABILITY (RED)

4 **Danger**	Flammable gas or extremely flammable liquid
3 **Warning**	Flammable liquid flash point below 100°F
2 **Caution**	Combustible liquid flash point of 100° to 200°F
1	Combustible if heated
0	Not combustible

HEALTH (BLUE)

4 **Danger**	May be fatal on short exposure. Specialized equipment required
3 **Warning**	Corrosive or toxic. Avoid skin contact or inhalation
2 **Warning**	May be harmful if inhaled or absorbed
1 **Caution**	May be irritating
0	No unusual hazard



REACTIVITY (YELLOW)

4 **Danger**	Explosive material at room temperature
3 **Danger**	May be explosive if shocked, heated under confinement, or mixed with water
2 **Warning**	Unstable or may react violently if mixed with water
1 **Caution**	May react if heated or mixed with water but not violently
0 **Stable**	Not reactive when mixed with water

SPECIAL NOTICE KEY (WHITE)

W	Water reactive
OX	Oxidizing Agent

Figure 9 General Rating Summary of NFPA Colors and Numbers

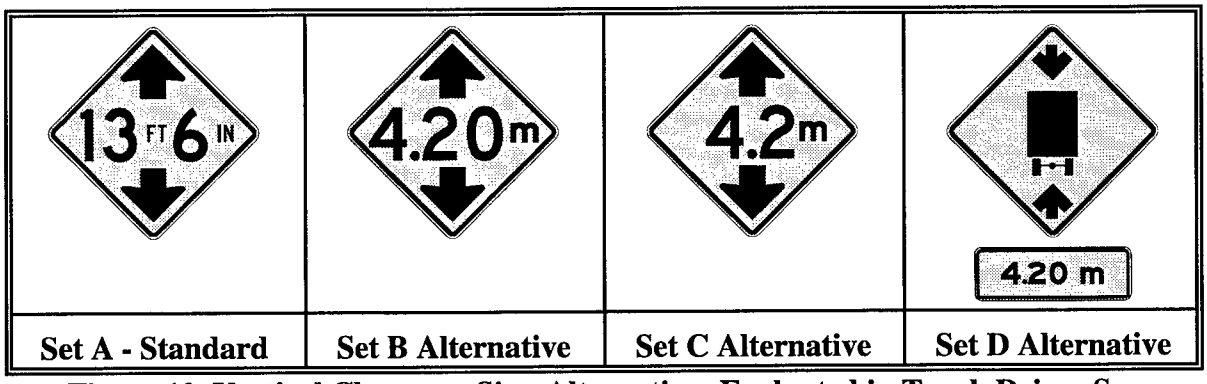


Figure 10 Vertical Clearance Sign Alternatives Evaluated in Truck Driver Survey

Weight Limit Signing. For weight limit signing, four alternatives were evaluated and are illustrated in Figure 11. The standard sign (R12-1) with the legend WEIGHT LIMIT 10 TONS was the alternative in Set A. The alternative with the legend MAXIMUM 10t (in Set B) was similar to the standard Canadian sign for weight limit (*7*). The Set C alternative was the standard Mexican weight limit sign (*6*). Set D was similar to the standard U.S. Weight Limit symbol sign (R12-5). A modification was made to the legend by placing the U.S. Customary weight limits of the three types of trucks on the left of the truck symbols and the equivalent weights in metric tons on the right side of the truck symbols. In addition to evaluating driver comprehension of the meaning of the weight limit signs, these alternatives were chosen to evaluate how well truck drivers understand the difference between U.S. tons (denoted by "T") and metric tonnes (denoted by "t").

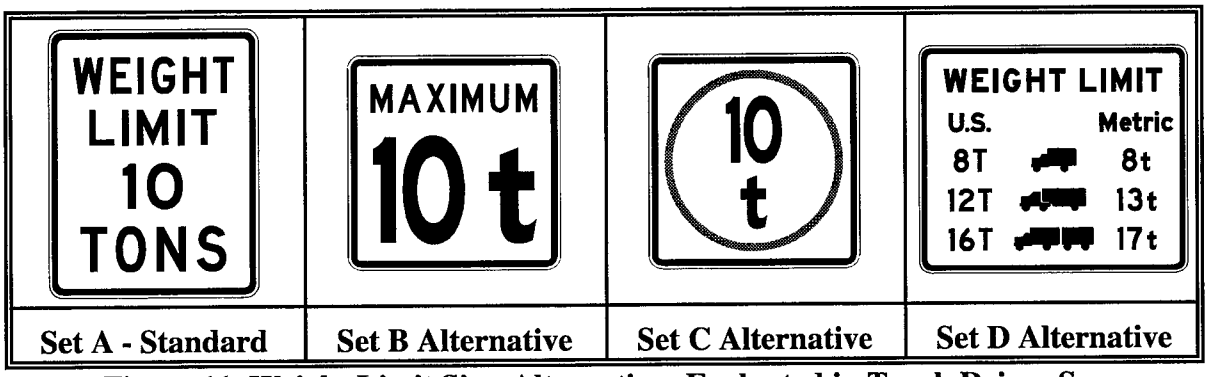


Figure 11 Weight Limit Sign Alternatives Evaluated in Truck Driver Survey

Load Zone Bridge Signing. Comprehension difficulties are possible for all truck drivers with the standard LOAD ZONE BRIDGE warning sign (W12-5) due to an unconventional message to indicate weight restrictions. The intended message can be especially confusing to Mexican truck drivers. Therefore, the researchers evaluated three word-message alternatives for this sign. Figure 12 illustrates these alternatives. The standard sign was evaluated in Set A. An alternative with the Spanish legend PUENTE DE PESO LIMITADO (meaning "bridge with a weight limit") was evaluated in Sets B and D. The legend commonly used in Mexico, PUENTE CON RESTRICCION DE CARGA (meaning "bridge with a load restriction"), was evaluated in Set C.

Figure 12 Load Zone Bridge Sign Alternatives Evaluated in Truck Driver Survey

Weigh Station Signing. Three alternatives were evaluated for the Weigh Station Exit Direction sign (D8-2) and are illustrated in Figure 13. The first was the U.S. standard sign (D8-2) that appears in Set A. For the Set B alternative, a line reading BASCULA, which is the Spanish translation for "weigh station," was inserted after the words WEIGH STATION in the standard sign. The third alternative, found in Sets C and D, adapted the Canadian symbol (with a slight modification) for a weigh station (*7*).

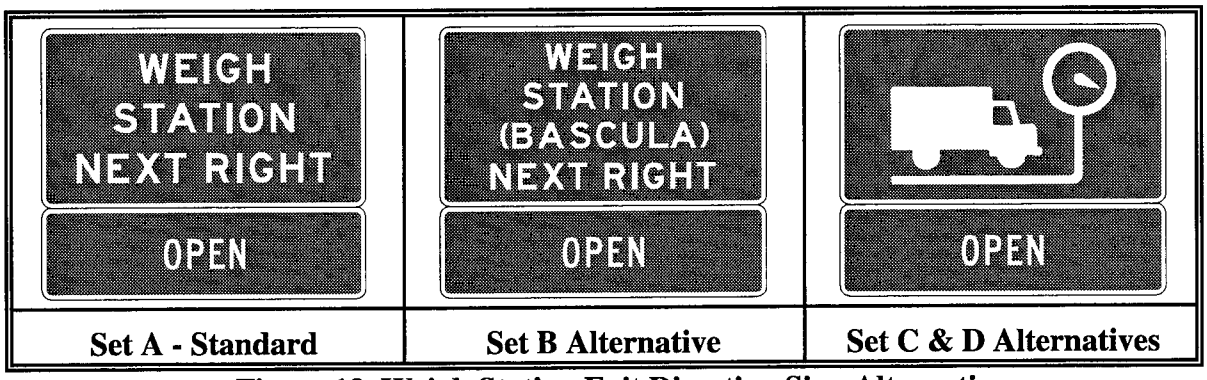


Figure 13 Weigh Station Exit Direction Sign Alternatives Evaluated in Truck Driver Survey

Literacy Evaluation. The researchers added a Spanish-legend sign, illustrated in Figure 14, to each of the four sets. Also illustrated in Figure 14 is the English translation of the same sign, which was not evaluated in the survey. The TxDOT Laredo District developed this Spanish-language sign for weigh station applications in the border area. Survey administrators asked participants to read and interpret the sign, and based on their response, they were able to indirectly assess the general Spanish literacy of the survey participants.

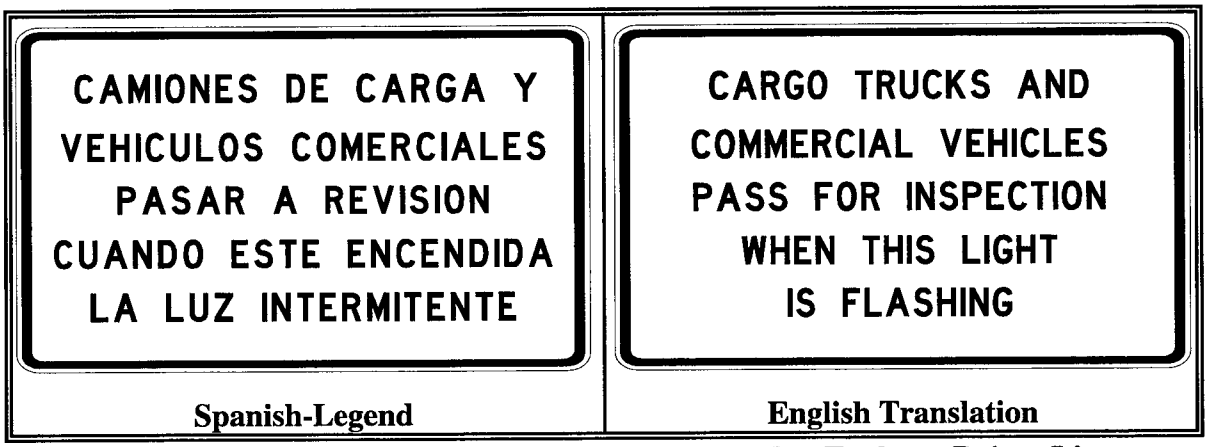


Figure 14 Spanish- and English-Legend Sign Used to Evaluate Driver Literacy

Truck and Hazardous Cargo Route Sign. The researchers added another truck-related sign to the survey, a sign that was recently developed by the TxDOT Laredo District. The sign,

illustrated in Figure 15, is a truck route and hazardous cargo educational sign intended to show the meaning of four truck-related traffic signs: the Hazardous Cargo sign (R14-2), the Hazardous Cargo Prohibition sign (R14-3), the No Trucks symbol sign (R5-2), and a "truck route" symbol sign (similar to the intended message of the National Network sign (R14-4)).

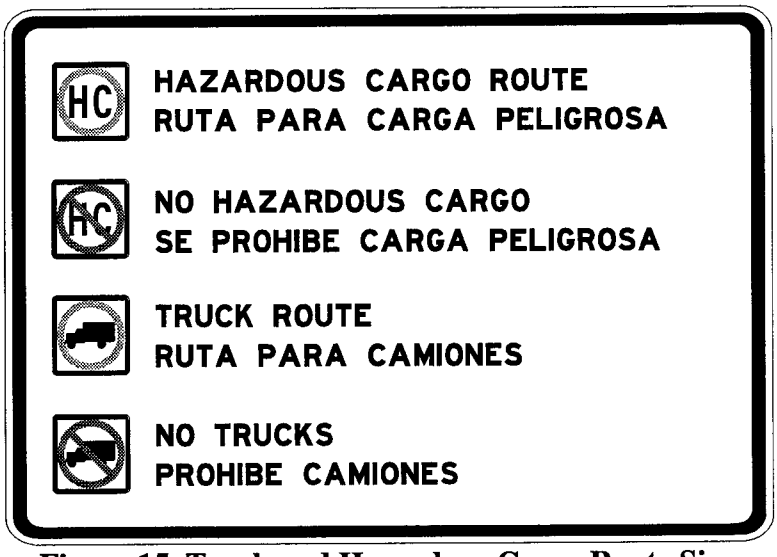


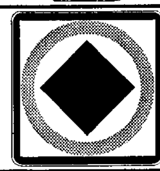
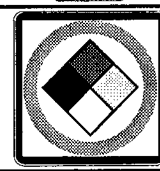
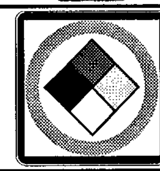
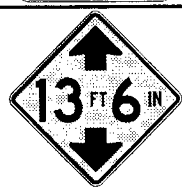
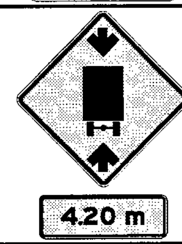
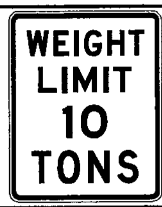
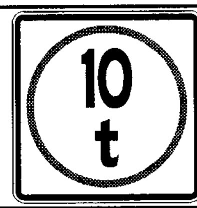
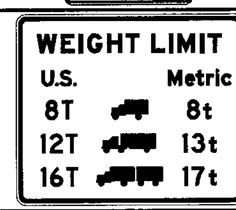
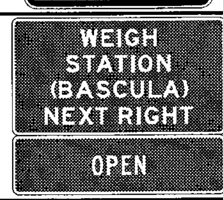
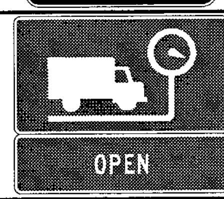
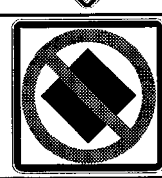
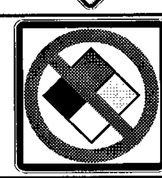
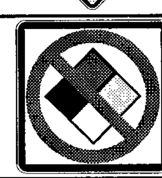
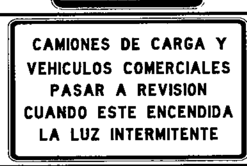
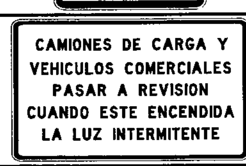
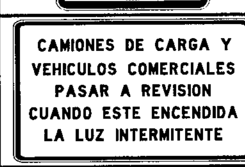
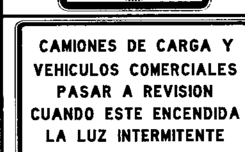
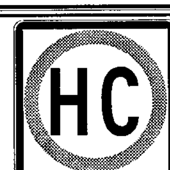
Figure 15 Truck and Hazardous Cargo Route Sign

The purpose of the Truck and Hazardous Cargo Route sign is to educate truck drivers on the intended meaning of the four devices depicted in this sign. The sign is to be primarily used on state-maintained highways in the Texas/Mexico border area, usually at major incoming routes into a city, including at border crossings. As of the publication of this report, this particular sign has not been installed on any highways in Texas; in fact, TxDOT has recommended that this sign, because of its size, be divided into two separate signs, one showing both Hazardous Cargo signs and one showing both Truck Route signs.

Survey Instrument Format

To evaluate the truck-related traffic signs, a survey instrument was again developed in a flash-card format. Four different survey sets (labeled A, B, C, and D, as shown in Table 2) were created with one alternative for each of the nine signs appearing in each set. Each flash-card consisted of a picture of a traffic sign on one side and comprehension-related questions on the opposite side. All questions were translated into Spanish before being placed on the flash-cards. Similar to the Texas driver survey, the participants' responses were audio recorded for future playback, data reduction, and analysis. Set A contained all of the current standard signs, while Sets B, C, and D contained the alternatives developed by the research team. Each survey participant was asked questions from only one of the survey sets, and the survey itself required approximately five minutes to complete.

Table 2 Organization of Truck Driver Survey

<table>
<tr><th>Question</th><th>Set A</th><th>Set B</th><th>Set C</th><th>Set D</th></tr>
<tr><td>1</td>
<td> 
</td>
<td> 
</td>
<td> 
</td>
<td> 
</td></tr>
<tr><td>2</td>
<td> 
</td>
<td>  </td>
<td>  </td>
<td>  </td></tr>
<tr><td>3</td>
<td> 
</td>
<td> 
</td>
<td> 
</td>
<td> 
</td></tr>
<tr><td>4</td>
<td> 
</td>
<td> 
</td>
<td> 
</td>
<td> 
</td></tr>
<tr><td>5</td>
<td> 
</td>
<td> 
</td>
<td> 
</td>
<td> 
</td></tr>
<tr><td>6</td>
<td> 
</td>
<td> 
</td>
<td> 
</td>
<td> 
</td></tr>
<tr><td>7</td>
<td> 
</td>
<td>  </td>
<td>  </td>
<td>  </td></tr>
<tr><td>8</td>
<td> 
</td>
<td> 
</td>
<td> 
</td>
<td> 
</td></tr>
<tr><td>9</td>
<td>  </td>
<td>  </td>
<td> 
</td>
<td> 
</td></tr>
</table>

Survey Administration

The truck driver survey was only administered in Laredo, Texas, at the Laredo/Colombia Solidarity Bridge, to truck drivers entering the United States. This bridge was selected as an optimal site for the survey based on the high volumes of commercial truck traffic. At the bridge, the survey was administered to the truck drivers as their trucks were being stopped for inspection by U.S. Customs officials.

Three researchers were present at the survey site to administer the surveys. Each administrator approached a truck driver who was typically waiting outside of the truck while the truck was being inspected. Participation was not required for this survey, but because of the delays experienced by the drivers, the survey administrators received very few rejections to participate.

In administering the survey, each participant was asked questions from only one of the four sets of signs, as presented in Table 2. To indirectly evaluate driver literacy, every participant was asked to interpret the Spanish-legend sign in Question 8. For Question 9 in each set, participants were asked to interpret only one of the four devices depicted in the Truck and Hazardous Cargo Route sign shown in Figure 15. Table 2 illustrates which devices were shown for each set.

DEMOGRAPHICS OF THE PHASE II SURVEYS

Prior to administering both the Texas and truck driver surveys, each survey administrator audio recorded certain demographic and other information about the driver, the passengers, and the vehicle. The following information was recorded for all drivers participating in the Texas driver survey:

- Age (approximate);
- Gender;
- Number of occupants; and
- Whether the participant drives more in Texas or in Mexico.

Besides age, gender, occupancy, and primary driving location, the administrators recorded the following additional information for all drivers participating in the truck driver survey:

- How many times per week the driver crosses the border to the United States;
- How far across the border in Texas the driver usually travels; and
- Driver literacy.

Table 3 presents the above information.

Table 3 Demographic Characteristics of Phase II Survey Evaluations

Phase II Survey Instrument		Texas Driver		Truck Driver	
Characteristics		**No.**	**%**	**No.**	**%**
Age	16 to 24	102	18.7	27	13.4
	25 to 54	399	73.1	111	55.0
	55 and over	36	6.6	4	2.0
	Data not available	9	1.6	60	29.7
Gender	Male	415	76.0	201	99.5
	Female	131	24.0	1	0.5
No. of Occupants	1 - Single Occupant	221	40.5	260	100
	2 - 4	294	53.8		
	> 5	12	2.2		
	Data not available	19	3.5		
Where They Do Most of Their Driving	Texas	416	76.2	64	22.8
	Mexico	32	5.9	88	36.6
	Both equally	87	15.9	102	37.9
	Data not available	11	2.0	6	4.0
Number of Border Crossings Per Week	1 to 10	n/a		62	30.7
	11 to 20			95	47.0
	20 to 50			44	21.8
	Data not available			1	0.5
How Far They Go After Crossing Texas Border	Within limits of Laredo free trade zone	n/a		152	75.2
	To other Texas cities along the border			32	15.8
	To cities beyond Texas free trade zone			14	6.9
	Data not available			4	2.0
Literacy*	Fully literate	n/a		156	77.2
	Partially literate			31	15.3
	Not literate			10	5.0
	Data not available			5	2.5
Total		546		260	

*Determined indirectly from responses to Question #8 in truck driver survey.

DATA REDUCTION AND ANALYSIS OF RESULTS

After completion of the survey processes, the researchers established criteria for reducing the data recorded on the audio cassettes. Since survey participants can demonstrate a wide range of understanding of one or more of the several concepts indicated by a given traffic control device, these criteria were important for understanding comprehension levels for specific concepts related to a sign.

Reduction of Survey Data

For the comprehension questions in both surveys, criteria was established for categorizing recorded responses as *correct* (full understanding), *partially correct* (partial understanding), *incorrect*, and *not sure*. A fifth category, *indeterminate*, was used if the responses on the tape were inaudible or if there were mechanical failures during the survey administration. For an answer to be placed in the *correct* category, the participant usually had to demonstrate a reasonably adequate understanding of a device's intended meaning and/or the required behavior necessary for compliance. For example, for a combination day/night, 70 miles per hour Speed Limit sign (R2-1, R2-3), shown in Figure 16, the participant had to know that the sign represented the maximum allowable speed that one could travel, that the sign's units were in miles per hour, and that the two different signs represented a day and night speed limit.

Figure 16 Day/Night Speed Limit Sign

If the participant could not demonstrate a reasonably adequate answer to the device's intended meaning, but still demonstrated limited understanding, the researchers would rank the response as *partially correct*.

To fully explore a driver's knowledge of traffic signs, the researchers established additional concepts of *correct criteria* for several signs in the truck driver survey. During the data reduction process, if a participant mentioned all criteria, the response was given a *correct* mark; if only one or more selected criteria were mentioned, but not all criteria, the response was given a *partially correct* response, but the specifically mentioned criteria were tabulated as well. Chapter 3 provides the detailed results of this analysis.

Statistical Analysis

Once the percentages of correct and partially correct responses were determined for each survey question, the researchers investigated the results of all devices. For the Texas driver survey, the comprehension results were tabulated, analyzed, and compared to the results from the Phase I study of Mexican drivers (*2*). For the truck driver survey, the results were again tabulated, and the results of the alternative signs were compared to those of the standard signs.

Researchers conducted statistical comparisons using the standard normal z-test. The test requires the assumptions that the sample population approximates the actual driving population and that the sample population can be characterized by the normal distribution. Larger sample sizes increase the confidence expressed by this test statistic. Using a 90 percent confidence interval for the z-test, a level of precision for the survey results can be calculated with formula in Equation (1).

$$\bar{x} = z_{\alpha/2}\,\sigma_{\hat{x}} \,, \tag{1}$$

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

The sample standard deviation can be calculated using the formula in Equation (2).

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

where: π = proportion of correct response, expressed as a percentage; and
n = sample size.

For example, assuming a 50 percent correct response rate (π=0.50), a sample size of 200 (n=200), and a 90 percent confidence interval ($\alpha = 0.10$, $z_{\alpha/2} = 1.645$) , the formula in Equation (3) can be used to determine the level of precision.

$$\bar{x} = z_{\alpha/2}\,\sigma_{\hat{\pi}} = 1.645\sqrt{\frac{0.5(1-0.5)}{(200)}} = \pm 5.8 \text{ percent.} \tag{3}$$

For both of the Phase II surveys, the researchers used the sample size of each survey and the correct response rates to establish the precision levels. Chapter 3 provides the results of these statistical analyses.

CHAPTER 3
DISCUSSION OF STUDY RESULTS

The Phase II Texas driver survey evaluated 30 different traffic control devices and was administered to a total of 546 Texas drivers at three international bridge crossing in the Texas/Mexico border area. The results of this survey were used to compare to the results of the Phase I survey of Mexican drivers at the same bridge crossings. Researchers administered a second survey to 260 truck drivers entering the U.S. at a predominantly-truck entry bridge in Laredo, Texas. The truck survey evaluation included nine standard truck-related traffic signs and several alternatives developed for each. This chapter provides the results of both surveys.

TEXAS DRIVER SURVEY

This section summarizes the study results of the Texas driver survey. The Phase II results, referred to as "Texas Drivers," are directly compared to the Phase I results, referred to as "Mexican Drivers." Tables 4 through 8 provide the results for the primary comprehension-related question asked for all traffic control devices. The tables indicate the results of *correct* plus *partially correct* responses (denoted by *C+P* in the tables), sample size (n), and precision. In addition, Tables 4 through 8 indicate whether or not a statistical or practical difference exists between the Mexican and Texas driver comprehension. A 90 percent confidence interval was used to establish levels of precision and significance. An indication of a practical difference was assumed to exist if the difference between Texas and Mexican drivers of (C+P) was greater than 10 percent. A complete tabulation of the results is provided in Appendix A.

Regulatory Signs

Researchers evaluated seven standard U.S. regulatory signs in the Phase II Texas driver survey. Table 4 presents the results for these seven signs, along with the corresponding results of the same signs from the Phase I survey of Mexican drivers.

STOP Sign. Over 97 percent of all study participants in the Phase II Texas driver survey understood the standard U.S. STOP sign. This high percentage compared similarly to the 98 percent demonstrated by Mexican drivers in the Phase I survey. No statistical or practical difference, however, exists between the two populations of drivers.

YIELD Sign. The Phase I survey results indicated that the standard U.S. YIELD sign presented considerable difficulties for Mexican drivers that participated in the first-year surveys (2). The Mexican drivers participating in the Phase I survey demonstrated significantly lower correct response rates than the Texas drivers in the Phase II survey. Approximately 80 percent of the Texas drivers understood and were able to effectively communicate the meaning of the YIELD sign, compared to only about 63 percent of the Mexican drivers. These differences are also statistically (and practically) significant at a 90 percent confidence interval, which suggests that either the Mexican drivers do not fully comprehend the meaning of the YIELD sign and/or cannot effectively communicate the meaning when asked.

Table 4 Survey Results for Regulatory Signs

Device	Mexican Drivers-1996			Texas Drivers-1997			Significance	
	C+P	n	Precision	C+P	n	Precision	Statistical [1]	Practical [2]
	98.7	600	0.8%	97.6	418	1.2%	No	No
	63.9	604	3.2%	80.6	418	3.2%	Yes	Yes
	97.5	599	1.0%	99.3	277	0.8%	No	No
	90.7	581	2.0%	96.1	413	1.6%	Yes	No
	83.3	553	2.6%	91.8	403	2.2%	Yes	No
	82.1	277	2.7%	90.4	386	2.5%	Yes	No
	56.4	157	3.4%	90.3	414	2.4%	Yes	Yes

[1] 90 percent confidence interval.
[2] Difference of greater than 10 percent.

Speed Limit Sign. Both the Mexican drivers and the Texas drivers demonstrated high correct response rates (nearly 100 percent) for the "speed limit" and "unit" (miles per hour) message concepts of the standard U.S. Speed Limit sign with the supplemental Night sign.

DO NOT ENTER Sign. The percentage of Mexican drivers (91 percent) in Phase I who understood the standard U.S. DO NOT ENTER sign was significantly lower (statistically) than the percentage of Texas drivers (96 percent). The *correct* plus *partially correct* response rates for both of these groups, however, were greater than 90 percent, so no practical difference exists. These results demonstrate that the DO NOT ENTER sign does not create comprehension difficulties for most Mexican and Texas drivers in the border area.

One Way Sign. The Mexican drivers in Phase I were found to demonstrate significantly lower comprehension levels than the Texas drivers in Phase II for the standard One Way sign. Approximately 83 percent of the Mexican drivers understood the correct meaning of the sign compared to 92 percent of the Texas drivers. Again, however, these differences do not appear to be of significant practical difference.

STOP FOR SCHOOL BUS LOADING OR UNLOADING Sign. The Mexican drivers in Phase I demonstrated a statistically lower correct response rate (82 percent) than the Phase II Texas drivers (90 percent). The results indicate, with confidence, that the English-legend sign presents comprehension difficulties for Mexican drivers, even though the sign was understood by relatively high percentages in both driving groups. Moreover, because of the more serious safety implications of misunderstanding this sign, researchers will conduct follow-up research on driver comprehension of this sign.

FASTEN SAFETY BELTS STATE LAW Sign. The *correct* plus *partially correct* response rate for the Mexican drivers in Phase I was significantly lower (56 percent) than the same rate for the Texas drivers in Phase II (90 percent). The all-English legend in this sign appears to create major comprehension difficulties for Mexican drivers, but by simple observation at the survey sites, many Mexican drivers appear to understand the seat belt law requirements in Texas. Mexico does not have a law that requires the use of a seat belt, but during the administration of both the Phase I and Phase II surveys, many northbound motorists (Mexican and U.S. citizens alike) were observed to buckle their seat belt on the approach to U.S. Customs inspection areas prior to entering into the United States. Regardless, researchers will still conduct additional evaluations of seat belt usage signs to improve understanding of the FASTEN SAFETY BELTS STATE LAW sign.

Warning Signs

Researchers evaluated six standard U.S. warning signs, two of which were construction warning signs with an orange background. Table 5 presents the results for these signs.

Curve, Two Way Traffic, and School Advance Signs. The Curve sign with the 35 M.P.H. sign supplement, the Two Way Traffic sign, and the School Advance sign all demonstrated high levels of comprehension (near or above 90 percent). A significant difference (statistically) was found between the Mexican and Texas drivers for the Curve and Two Way Traffic signs, but no practical difference existed between the two driver groups for all three signs.

Railroad Advance Warning Sign. The comprehension results of the Railroad Advance Warning sign indicated that Mexican drivers in Phase I demonstrated a poorer understanding of this sign as compared to the Texas drivers in Phase II. Nearly 80 percent of the Mexican driver sample correctly identified the meaning of this sign, compared to over 94 percent of the Texas drivers. Additional educational efforts may help to improve comprehension of this sign for the Mexican driver.

Table 5 Survey Results for Warning Signs

Device	Mexican Drivers-1996			Texas Drivers-1997			Significance	
	C+P	n	Precision	C+P	n	Precision	Statistical	Practical
	96.2	526	1.4%	92.6	380	2.2%	Yes	No
	93.9	534	1.7%	87.3	378	2.8%	Yes	No
	79.6	603	2.7	94.2	414	1.9	Yes	Yes
	86.6	545	2.4	90.2	386	2.5	No	No
	20.1	502	2.9	25.3	241	4.6	No	No
	81.3	579	2.7	89.8	420	2.4	Yes	No

RIGHT LANE ENDS Signs. The Phase II survey results of Texas drivers indicated that very few drivers, at least in the border area, understand the meaning of the use of the color of orange for construction and maintenance work zone devices. When asked of the difference between two different RIGHT LANE ENDS signs—one orange and one yellow—only 25 percent of the study participants were able to indicate that the orange sign was used exclusively for construction and maintenance work zones (see Appendix A). Only 20 percent of the participants in the Phase I survey of Mexican drivers indicated a correct response to this question. Some study participants may have been confused by the question asked ("What is the difference between these two signs?"), but the results nevertheless indicate a deficiency in comprehension of identifying work zone activity and, possibly, the appropriate driving behaviors.

ROAD WORK AHEAD Sign. The *correct* and *partially correct* response rates of the Mexican drivers in Phase I (81 percent) were statistically lower than the response rates of the Texas drivers in Phase II (90 percent). The results, however, were not of practical significance.

Pavement Marking Scenarios

Researchers evaluated five different pavement marking scenarios. The scenarios shown to the survey participants depicted a three-dimensional illustration of a roadway, each with a different configuration of pavement markings and vehicles. Table 6 presents the results for these signs.

Table 6 Survey Results for Pavement Marking Scenarios

Device	Mexican Drivers-1996			Texas Drivers-1997			Significance	
	C+P	n	Precision	C+P	n	Precision	Statistical	Practical
Broken White Lane Line - One-Way vs. Two-Way	51.5	505	3.7%	48.3	236	5.4%	No	No
Broken White Lane Line - Passing	81.8	490	2.9%	92.9	410	2.1%	Yes	Yes
Broken Yellow Centerline - One-Way vs. Two-Way	72.2	593	3.0%	83.2	417	3.0%	Yes	Yes
Broken Yellow Centerline - Passing	74.8	589	2.9%	78.4	416	3.3%	No	No
No Passing Zone - Passing	84.1	573	2.5%	89.0	408	2.5%	No	No

One-Way vs. Two-Way Roadway with White Lane Line. A broken, white line pavement marking scenario, depicting a two-lane roadway, was shown to the survey participants in both the Phase I and Phase II surveys. Participants were asked to indicate if the roadway was a one-way or two-way road. The results indicated that both driving groups (Mexican and Texas) demonstrated comprehension difficulties with this scenario. *Correct* plus *partially correct* response rates were only about 50 percent for each group.

Passing on One-Way Roadway. Again, the same scenario of broken, white line pavement markings on a two-lane roadway was shown to the survey participants. This scenario, however, also depicted two vehicles on the roadway, both in the right lane. Participants were asked to indicate whether or not the vehicle to the rear was legally permitted to pass the vehicle in the front. Approximately 82 percent of the Mexican drivers in the Phase I survey and 93 percent of the Texas drivers in the Phase II survey answered correctly for this scenario. The difference in results between these groups is also statistically significant, with the Texas drivers demonstrating a better understanding of the broken white lane line.

One-Way vs. Two-Way Roadway with Broken Yellow Centerline. Similar to the questioning for the broken white lane line scenario, drivers in both groups demonstrated an improved understanding of the broken yellow centerline to distinguish between a and two-way roadway. Again, however, Texas drivers proved to better understand the concept, with over 83 percent providing the correct answer, compared to approximately 72 percent of the Mexican drivers in Phase I.

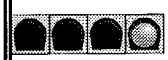
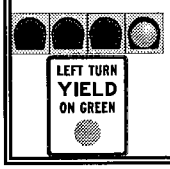
Passing on a Two-Way Roadway. Similar to the one-way roadway passing scenario, Mexican and Texas drivers demonstrated *correct* plus *partially correct* response rates of 75 and 78 percent, respectively, for the understanding of the broken yellow centerline for passing purposes. The results of the two groups were not significantly different.

No Passing Zone. The final scenario depicted a two-lane roadway and a no passing zone, as well as showing two vehicles in the right lane. Survey participants were asked to indicate whether or not the vehicle in the rear was legally permitted to pass the vehicle in the front (with the correct answer being "no"). Both the Mexican and Texas driving groups appeared to understand this scenario well, with over 84 percent of the Mexican drivers and 89 percent of the Texas drivers providing correct responses. The difference in results between the two groups was not statistically significant.

Signal Displays

Researchers evaluated three basic signal displays (red, yellow, and green ball) and four more complex signal displays (with and without signing) for protected and permissive left turns. Table 7 presents the results for these signal and sign displays.

Table 7 Survey Results for Basic and Left Turn Signal Displays

Device	Mexican Drivers-1996			Texas Drivers-1997			Significance	
	C+P	n	Precision	C+P	n	Precision	Statistical	Practical
	97.7	601	1.0%	99.5	417	0.6%	Yes	No
	97.7	599	1.0%	98.8	417	0.9%	No	No
	97.6	596	1.0%	99.5	418	0.6%	Yes	No
	80.8	587	2.7%	85.9	412	2.8%	No	No
	79.0	534	2.9%	86.0	386	2.9%	Yes	No
	72.1	563	3.1%	94.6	406	1.8%	Yes	Yes
	78.2	499	3.0%	87.8	238	3.5%	Yes	No

Red, Yellow, and Green Ball Signal Displays. As expected, because of similar usage in Mexico and the U.S., a high level of comprehension (96 percent correct or above) was demonstrated for the red, yellow, and green ball signal displays for both the Mexican and Texas driving groups.

Protected Left Turn Signal and Sign Displays. The green "left arrow" signal display with the Protected Left on Green Arrow sign significantly improved comprehension over just the green "left arrow" signal display alone for the Phase I Texas participants. Texas drivers also demonstrated a better understanding of the signal/sign display than the Mexican driving group from Phase I. The addition of the sign, however, significantly decreased comprehension for this Mexican driving group.

Permissive Left Turn Signal and Sign Displays. The correct response rates demonstrated by the Texas driving group were statistically equivalent for the green "ball" signal display with and without the Left Turn YIELD on Green (Ball) sign, with *correct* plus *partially correct* response rates of 88 and 86 percent, respectively. The Phase I Mexican drivers demonstrated significantly lower comprehension levels than the Texas drivers for both signal displays with and without the supplemental sign (78 and 79 percent, respectively). The difference in results between the two driving groups, however, is of no practical significance.

Spanish-Language Alternative Devices

Researchers also evaluated five different Spanish-language alternative signs that were not evaluated in the Phase I survey of Mexican drivers. These five devices included the Mexican YIELD sign (CEDA EL PASO sign), Spanish-language equivalents of the Speed Limit sign and STOP FOR SCHOOL BUS LOADING OR UNLOADING sign, and two Spanish-language alternatives to the standard FASTEN SAFETY BELTS STATE LAW sign. Table 8 presents the results for these five signs.

CEDA EL PASO Sign. The standard Mexican YIELD sign (CEDA EL PASO) was evaluated as a potential alternative to the U.S. YIELD sign. There was no significant difference, however, between the comprehension of the U.S. YIELD sign and the Mexican CEDA EL PASO alternative for the Texas drivers in Phase II.

Speed Limit Sign Alternative. A Spanish-language alternative that contained the legend *Velocidad Maxima* (instead of Speed Limit) and *Noche* (instead of Night) was evaluated for the Speed Limit sign with the Night supplement. The units, however, remained the same in each. This Spanish-legend alternative, however, did not significantly improve or hinder the comprehension of the sign or interpretation of the units for the Texas driver participants. In fact, it performed equally as well as the U.S. sign.

STOP FOR SCHOOL BUS LOADING OR UNLOADING Sign. A Spanish-legend alternative (ALTO PARA AUTOBUS ESCOLAR SUBIENDO O BAJANDO PASAJE) was evaluated in the Phase II survey of Texas drivers. Designed more specifically for Mexican drivers who may not be able to speak and/or read the English language, this alternative did not have a negative effect on comprehension by the Texas drivers.

Table 8 Survey Results for Spanish-Language Signs

Device	Mexican Drivers-1996	Texas Drivers-1997			Significance
		C+P	n	Precision	
	Not Evaluated	85.2	229	3.9%	Not Tested
		98.5	395	1.0%	
		94.6	404	1.8%	
		80.2	243	4.2%	
		88.3	231	3.5%	

FASTEN SAFETY BELTS STATE LAW Sign. Two Spanish-legend alternatives were evaluated for the standard U.S. sign. The first alternative contained the legend LA LEY EXIGE EL USO DEL CINTURON SEGURIDAD. For the Texas drivers, *correct* plus *partially correct* comprehension levels were significantly lower for this alternative (80 percent) than for the standard U.S. sign (90 percent). The second alternative, with the legend ABROCHESE EL CINTURON DE SEGURIDAD LEY ESTATAL, demonstrated some improvement over the first alternative, with a *correct* plus *partially correct* response rate over 88 percent.

TRUCK DRIVER SURVEY

The results discussed here are based on the responses of 260 truck drivers interviewed at the Laredo/Colombia Solidarity Bridge in Laredo, Texas. Following administration of the survey, the researchers analyzed the data to determine if any of the alternatives exhibited significant improvement in comprehension levels over the standard sign. A complete tabulation of the truck driver survey results is provided in Appendix B.

Truck Speed Limit Signing

The survey questions for the Truck Speed Limit sign were intended to evaluate several concepts involved with the full understanding of this sign. Table 9 presents the correct response rates for each alternative. For all four alternatives, truck drivers had a very high understanding (above 90 percent correct response rate) of the concepts that the sign conveys a posted speed

limit, that the speed is in miles per hour, and that the regulatory sign applies to trucks only. Most of the drivers understood the reason for the two different speed limits (one for day, one for night), as the correct response rate for this question was between 80 and 90 percent for all four alternatives. Larger differences in correct response rates were found for the concept of the speed limit applying only to trucks. For this question (Follow-up Question #2), the alternative with the truck symbol (C1) had the highest average correct response rate. Based on the preliminary results, however, the differences among correct response rates for the four alternatives were not found to be significant for any of the questions related to the Truck Speed Limit signs.

Table 9 Survey Results for Truck Speed Limit Signing

SIGN ALTERNATIVE				QUESTIONS* AND CORRECT RESPONSES
A1	B1	C1	D1	
				
				#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
76.7	84.4	91.9	75.4	**#2: What types of vehicles must obey this sign?** Trucks
96.6	94.9	98.4	94.4	**#3: Is the speed in kilometers or miles per hour?** Miles per hour.
79.7	81.7	90.0	87.7	**#4: Why are there two different numbers?** Day and night/dark.
100.0	100.0	100.0	100.0	**#5: Does this sign apply to you?** Yes/sure
± 2.8%	± 9.8%	± 4.8%	0.0	Precision
65	66	66	62	Sample Size

Hazardous Cargo Signing

The standard Hazardous Cargo Route sign had a very low comprehension level among Texas border-area truck drivers. The alternative with the multi-colored "diamond" (Alternatives C2 and D2) showed a statistically significant improvement over the standard sign, a surprising result for a new symbol that has not been used before on signs. The correct response rate, however, for all three alternatives was much lower than desired, as provided in Table 10. The low comprehension rate for all alternatives appears to indicate a difficulty in communicating the intended meaning of this sign.

Table 10 Survey Results for Hazardous Cargo Signing

SIGN ALTERNATIVE			QUESTIONS* AND CORRECT RESPONSES
A2	B2	C2/D2	
			
12.3	3.0	29.9	**#1: What does this sign mean?** *Correct* Identifies hazardous cargo route. *Partially Correct* No acceptable response.
6.2 81.5 0.0	4.5 92.4 0.0	9.4 60.6 0.8	Incorrect Not Sure Unknown
60.0	100.0	39.1	**#2: What should you do if you see this sign on the road?** Follow this route if I am carrying hazardous cargo.
± 7.9	± 5.4	± 7.1	Precision
65	66	127	Sample Size

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

For truck drivers to legally carry hazardous materials into the United States, they must complete an educational program which teaches them about the traffic signs related to hazardous cargo. Many of the drivers who participated in this survey claimed that since they never carry hazardous cargo, they have never received the training related to hazardous cargo and were thus unfamiliar with hazardous cargo-related signs. Therefore, the low comprehension rates shown do not necessarily indicate a deficiency in understanding among the population of truck drivers who carry hazardous cargo. Future study efforts should focus on distinguishing comprehension rates between truck drivers with and without hazardous cargo.

Hazardous Cargo Prohibition Signing

The results for the standard Hazardous Cargo Prohibition sign showed a significant deficiency in understanding, as shown in Table 11. Additional research efforts may be necessary for this sign to develop better-understood alternatives.

Table 11 Survey Results for Hazardous Cargo Prohibition Signing

SIGN ALTERNATIVE			QUESTIONS* AND CORRECT RESPONSES
A7	B7	C7/D7	
			
12.5	1.5	24.4	**#1: What does this sign mean?** *Correct* Vehicles with hazardous cargo are not allowed on this road, hazardous cargo prohibited, or no hazardous cargo. *Partially Correct* No acceptable response.
1.6 76.6 0.0	3.1 66.2 0.0	4.1 60.2 0.0	Incorrect Not Sure Unknown
80.0	0.0	83.3	**#2: What should you do if you see this sign on the road?** Do not follow this route if I am carrying hazardous cargo.
± 8.7	± 9.7	± 7.3	Precision
64	65	123	Sample Size

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

Clearance Signing

The data for the Clearance sign, provided in Table 12, showed that more than 80 percent of the truck drivers understood that the sign refers to the height of a structure or bridge ahead. Both alternatives with the legends reading "4.20 m" (Alternatives B3 and D3) showed a significant increase in understanding over the standard sign (Alternative A3) for the concepts of correct units and correct understanding of the numeric height indicated (see Table 12). The data from the survey indicates that the legend reading "4.20 m" may be easier to understand than the legend reading "4.2 m." Many of the truck drivers misunderstood the two numbers (for feet and inches) indicated by the standard sign, believing that one number was for maximum height and the other for maximum width. Some drivers misunderstood the number legend of "4.2 m" in Alternative C3 because they thought that it meant "4 meters" and "2 centimeters," rather than "4 meters" and "20 centimeters."

Table 12 Survey Results for Clearance Signing

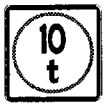
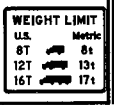
SIGN ALTERNATIVE				QUESTIONS* AND CORRECT RESPONSES
A3	B3	C3	D3	
				
				#1: What does this sign mean?
				Correct
9.2	21.2	18.5	9.7	All criteria at first glance.
				Partially Correct
81.5	89.4	87.7	80.6	Bridge or structure, clear height
13.8	30.3	26.2	19.4	Height of "13, 6" (A3) or "4.20" (B3, C3, 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
± 9.0	± 9.4	± 9.1	± 9.1	Precision
65	66	65	62	Sample Size

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

Weight Limit Signing

The results for the standard WEIGHT LIMIT 10 TONS sign, provided in Table 13, show that approximately 80 percent of the respondents understood that the sign referred to a "weight limit." The comprehension rate for the standard sign was much higher than the comprehension rates for Alternatives B4 and C4. The questions on the comprehension of the units in the signs for all four alternatives showed that the majority of the truck drivers do not understand the difference between U.S. tons and metric tonnes. In addition, the truck drivers were unaware of the convention of using an upper-case "T" to denote U.S. tons and a lower-case "t" to denote metric tonnes. The main reason for the low level of understanding of the standard WEIGHT LIMIT 10 TONS sign is probably the all-English word legend. Since a very high level of literacy was found among the participants in the survey, it is recommended that alternatives with Spanish-word legends be tested in future research.

Table 13 Survey Results for Weight Limit Signing

SIGN ALTERNATIVE				QUESTIONS* AND CORRECT RESPONSES
A4	B4	C4	D1	
				
66.2 78.5 69.2	22.7 22.7 22.7	3.1 3.1 7.7	14.5 50.0 0.0	**#1: What does this sign mean?** *Correct* All criteria at first glance. *Partially Correct* Weight limit 10 tons (A4,B4,C4) or different trucks (D4)
4.6 13.8 0.0	22.7 54.5 0.0	24.6 67.7 0.0	24.2 25.8 0.0	Incorrect Not Sure 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	 62.1	**#3: Are these U.S. or metric tons?** U.S. tons (A4) and metric tonnes (B4 and C4) **#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 61.1	**#4: How much is a U.S. ton?** 2000 lbs, 2200 lbs, 1000 kg, or 900 kg (A4, B4, and C4) **#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
± 9.7%	± 10.1%	± 9.5%	± 10%	Precision
65	66	65	62	Sample Size

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

Weigh Station Signing

As shown in Table 14, only 36 percent (*correct* plus *partially correct*) of the truck drivers understood that the standard Weigh Station Exit Direction sign referred to a weigh station. The addition of the Spanish word BASCULA (meaning "weigh station") to the standard sign for Alternative B5 increased understanding to 98 percent (*C+P*). The alternative used in Sets C and D (which uses the Canadian symbol for weigh station) had lower comprehension levels than the standard sign.

Table 14 Survey Results for Weigh Station Signing

SIGN ALTERNATIVE			QUESTIONS* AND CORRECT RESPONSES
A5	B5	C5/D5	
			
12.1 24.2	33.3 65.2	14.2 28.3	**#1: What does this sign mean?** *Correct* Weigh station open AND trucks must stop to be weighed. *Partially Correct* Weigh station open OR trucks must stop to be weighed.
9.1 54.5 0.0	0.0 1.5 0.0	19.7 37.8 0.0	Incorrect Not Sure Unknown
100.0	100.0	100.0	**#2: What is a weigh station?** Place where trucks are weighed.
96.7	83.7	83.3	**#3: What vehicles must go through the weigh station?** Trucks
± 10.1%	± 9.7%	± 7.1%	Precision
66	66	127	Sample Size

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

Load Zone Bridge Signing

As presented in Table 15, the alternatives which used Spanish-word legends (Alternatives B6/D6 and C6) demonstrated significant increases in comprehension levels over the standard LOAD ZONED BRIDGE sign (Alternative A6). When the drivers understood the meaning of the sign, they also had a better understanding of how to respond to that sign upon observing it on the road (Follow-up Question #2). The alternative used in Sets B and D (PUENTE DE PESO LIMITADO) had higher correct response rates than alternative C6 (PUENTE CON RESTRICCION DE CARGA).

Table 15 Survey Results for Load Zone Bridge Signing

SIGN ALTERNATIVE			QUESTIONS* AND CORRECT RESPONSES
A6	B6/D6	C6	
			
			#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.
± 9.9%	± 4.8%	± 9.2%	Precision
65	127	65	Sample Size

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

Truck and Hazardous Cargo Route Signing

The research team evaluated four components of a truck and hazardous cargo route sign. The components, evaluated separately in each set of the survey, consisted of questioning related to the comprehension of the following symbol signs:

- Survey Set A - "truck route" sign, similar to the National Network sign (R14-4);
- Survey Set B - No Trucks sign (R5-2);

- Survey Set C - Hazardous Cargo sign (R14-2); and
- Survey Set D - Hazardous Cargo Prohibition sign (R14-3).

Each sign was also supplemented with an English- and Spanish-word legend that explained the symbol in the sign. This supplemental text is presented in Table 16. Truck drivers were shown a picture of the entire sign (see Figure 15), but the survey administrator would only designate one component of the sign (symbol sign and supplemental legend) for the truck driver to explain. The designated component varied depending upon the survey set.

Table 16 Symbol Sign and Supplemental Legend Text for Truck and Hazardous Cargo Route Sign

Survey Set	Symbol Sign	Supplemental Text	
A		English Spanish	TRUCK ROUTE RUTA PARA CAMIONES
B		English Spanish	NO TRUCKS PROHIBE CAMIONES
C		English Spanish	HAZARDOUS CARGO ROUTE RUTA PARA CARGA PELIGROSA
D		English Spanish	NO HAZARDOUS CARGO SE PROHIBE CARGA PELIGROSA

The results of the truck driver survey for the four different sign components are presented in Table 17. The supplemental legend text in the sign significantly improved the understanding of the intended meaning of each of the symbol signs, compared to what might have been demonstrated without the supplemental text. The comprehension rate of both Hazardous Cargo Route signs (Alternatives C9 and D9) was significantly greater than what the truck drivers demonstrated for the same two signs shown in Set A (Alternatives A2 and A7) without the supplemental text (see Tables 10 and 11) . For the two Hazardous Cargo Route signs with supplemental text, the truck drivers demonstrated a *correct* response rate of more than 90 percent, compared to only 12 percent of the drivers who correctly understood the same two signs without the supplemental text. Truck drivers also demonstrated high *correct* response rates for

the No Trucks sign (Alternative A9) and the "truck route" sign (Alternative B9), with both rates exceeding 90 percent. The high rate can likely be attributed to the supplemental text that was part of the sign.

Table 17 Survey Results for Truck and Hazardous Cargo Routing Signing

SIGN ALTERNATIVE				QUESTIONS AND CORRECT RESPONSES
A9	B9	C9	D9	
				
96.9	95.4	92.2	93.1	**#1: What does this sign and phrase mean?** *Correct* Truck route OR road for trucks. No truck on this route. Vehicles with HC must follow sign OR identifies a HC route. Vehicles w/HC not allowed on road, HC prohibited, OR no HC
0.0	0.0	0.0	0.0	*Partially Correct* No acceptable response.
3.1	4.6	6.3	5.2	Incorrect
0.0	0.0	1.6	1.7	Not Sure
0.0	0.0	0.0	0.0	Unknown
± 9.0	± 9.4	± 9.1	± 9.1	Precision
64	65	64	58	Sample Size

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

LITERACY EVALUATION

The research team used the Spanish-language sign developed by the TxDOT Laredo District for weigh station applications in the border area to indirectly evaluate truck driver literacy. Survey administrators asked participants to read and interpret the sign, and based on their response, were able to indirectly assess the general literacy of the survey participants. Over 80 percent of the truck drivers correctly interpreted the sign's message. This percentage compares similarly to Mexico's overall average literacy rate among its citizens (*8*).

CHAPTER 4
RESEARCH RECOMMENDATIONS

The following sections summarize the recommendations and conclusions from the Phase II research studies.

REGULATORY SIGNS

The following recommendations are made for regulatory signs evaluated during the Phase II research studies:

• STOP sign (R1-1)	No further evaluation or implementation recommendations;
• YIELD sign (R1-2)	Need more comprehension and field observation evaluations;
• Speed Limit sign (R1-2, R1-3)	No further evaluation or implementation recommendations for this sign or Truck Speed Limit sign;
• One Way sign (R6-1)	No further evaluation or implementation recommendations;
• STOP FOR SCHOOL BUS LOADING OR UNLOADING sign (R19-1)	There is a need for a Spanish-legend version of this sign. The Spanish legend evaluated in the survey, however, can be improved. The English-legend version of this sign may also need improving; and
• FASTEN SAFETY BELT STATE LAW sign (R19-8)	The Spanish-legend alternative evaluated in this survey, ABROCHESE EL CINTURON DE SEGURIDAD, indicated that there is some value using a Spanish legend for this sign. The researchers should determine if this legend could be improved upon. If it can, further evaluations may be needed. If the Spanish version is used in practice, it can be mounted side-by-side with the English at low-speed locations. At high speed locations, the signs should be placed at independent, alternating locations.

WARNING SIGNS

The following recommendations are made for warning signs evaluated during the Phase II research studies:

• Curve sign (W1-2)	No further evaluation or implementation recommendations;
• Two Way Traffic sign (W6-3)	No further evaluation or implementation recommendations;
• Railroad Advance Warning sign (W10-1)	No further evaluation or implementation recommendations. Research Report 1261-5 indicated that the use of a distance plaque below the sign increases comprehension (*4*). TxDOT should emphasize this recommendation;
• School Advance sign (S1-1)	No further evaluation or implementation recommendations;
• RIGHT LANE ENDS sign (W9-1R, CW9-1R)	The researchers should conduct additional evaluations of signs indicating the end of a lane;
• ROAD WORK AHEAD sign (CW21-4D)	No further evaluation or implementation recommendations; and
• Yellow/Orange Color for Warning and Construction Warning signs	Although the difference between yellow and orange signs was not understood by many drivers, there are no engineering improvements that would increase comprehension. The meaning of sign color should receive greater emphasis in driver education/training curriculums. This is a subject that will be considered as part of TxDOT Project 1794.

PAVEMENT MARKINGS

Although the comprehension of some markings could be improved, there are no engineering improvements that would increase comprehension. The meaning of pavement markings should receive greater emphasis in driver education and training curriculums. A

current TxDOT research study, Project 1794, "Driver Education Program for Traffic Control Devices," will focus on the comprehension improvement of pavement markings.

SIGNAL DISPLAYS

The basic signal indications are well understood. No further evaluation is recommended for the red, yellow, and green ball signal displays. For left turn indications, the green arrow and ball without a sign is well understood.

The Left Turn Yield on Green Ball sign (R10-12) appears to be better understood than the Protected Left on Green Arrow sign (R10-9). The improvement is consistent with the findings of the TxDOT/TTI 1261 research (*5*). TxDOT should emphasize that, when a sign is used, the R10-12 sign is the preferred sign for indicating protected/permitted left turn signal phasing.

TRUCK SIGNING

Due to the special linguistic and cultural characteristics of drivers near the Texas border with Mexico, alternative designs to standard traffic control devices can be developed to improve the comprehension levels in the border areas. The results of the truck driver survey demonstrated that signs consisting of all-English-language legends, such as the LOAD ZONED BRIDGE sign and the WEIGH STATION NEXT RIGHT sign, were difficult for most of the border-area truck drivers to understand. Conversely, the alternatives that included Spanish-word legends had a much higher comprehension rate than the all-English standard signs.

The effectiveness of Spanish-word legend signs depend on the literacy rate of the drivers; a high level of literacy was found among the truck drivers interviewed in Laredo. Since the literacy rate may vary, however, for truck drivers crossing the border in other parts of Texas, more studies of literacy and driver comprehension of Spanish-legend signs may be necessary prior to any widespread implementation of bilingual signing.

Several standard signs were found to have very low comprehension levels (correct response rates lower than 50 percent) among the border-area truck drivers. The standard signs with very low levels of understanding were the Hazardous Cargo Route sign (R14-2), the Hazardous Cargo Prohibition sign (R14-3), the Weigh Station Exit Direction sign (D8-2), and the LOAD ZONED BRIDGE sign (W12-5). Improved education programs and improved alternatives should be researched and developed for the standard signs that have low comprehension levels.

Truck Speed Limit Signing

Researchers will conduct no further evaluations or make any specific implementation recommendations for this sign.

Hazardous Cargo Route and Prohibition Signing

The multi-colored "diamond" fire hazard symbol appears to have significant value in improving comprehension. In January 1998, the research team presented the two signs to the Regulatory/Warning Sign Technical Committee of the National Committee on Uniform Traffic Control Devices. The committee members indicated support for the concept, but felt that the research data was insufficient to recommend implementation. The sample size was too small and represented a limited geographic portion of the country. Furthermore, even the improved comprehension levels (25 to 30 percent) are still much lower than desirable. The researchers will further investigate Hazardous Cargo signing alternatives in the third year of research and evaluate the signing with U.S. truck drivers in non-border areas.

Clearance Signing

TxDOT should continue to use the current Clearance warning sign. TxDOT should emphasize the need to use "FT" (feet) and "IN" (inches) in the legend instead of using the "tick" symbol marks. In border areas, Clearance signs should have the metric clearance dimension as a supplemental plaque below the sign. A separate metric version of the sign should not be used. The research team will disseminate information to FHWA on the Clearance sign to indicate that Mexican truck drivers understand dimensions with two decimal places better than dimensions with one decimal place.

Weight Limit Signing

The TxDOT Advisory Panel and the research team agreed to include the Weight Limit sign and alternatives in future assessment efforts related to the LOAD ZONED BRIDGE sign.

Weigh Station Signing

Even though the use of a Spanish word *bascula* in the standard sign greatly improved driver comprehension, it is recommended that Spanish and English not be used in the same sign. A separate all-Spanish legend sign should be developed, or changes should be made to the placement and/or style of the Spanish word on the U.S. sign. Many truck drivers had trouble identifying the presence of the word *bascula* between the English words in the bilingual alternative. The researchers will further investigate Spanish-legend alternatives for this sign.

Load Zoned Bridge Signing

There is a need for one of the Spanish-legend versions of this sign: PUENTE DE PESO LIMITADO. The TxDOT Advisory Panel and the researchers have indicated a general dislike of the U.S. version of the sign. The researchers recommend a general assessment of the sign and its use(s), then developing alternatives for further evaluation. The actual regulatory weight limit should have some association with this warning sign.

Truck and Hazardous Cargo Route Signing

TxDOT determined that the Truck and Hazardous Cargo Route sign, developed by the Laredo District, should be split into two separate signs. The signs should be installed at the border crossings and on major highways entering cities. The city must have officially established hazardous cargo routes and truck prohibitions before installing the two signs.

CONCLUSIONS

Researchers at TTI and University of Texas Pan American will collaborate research efforts during the third and final year of this project. Research efforts will likely include: 1) surveys of border-area drivers for a select number of signs; 2) surveys of truck drivers operating in non-border areas for a select number of truck-related signs; and 3) operational/compliance studies of drivers at specific geometric locations (i.e., frontage roads, four-legged intersections) where YIELD signs are installed and alternative YIELD sign applications can be studied.

CHAPTER 5
REFERENCES

1. *Texas Manual on Uniform Traffic Control Devices.* Texas Department of Highways and Public Transportation, Austin, Texas, 1980, revised through 1997.

2. Hawkins, H. Gene, Jr., D. L. Picha, B. L. Mann, C. R. McIlroy, K. N. Womack, and C. L. Dudek. *Assessment of Mexican Driver Understanding of Existing Traffic Control Devices Used in Texas.* Research Report FHWA/TX-97/1274-1, Texas Transportation Institute. College Station, Texas, November 1996.

3. Weissmann, Angela Jannini, R. Harrison, M. Trevino, and S. Mandava. *Texas' Role as a U.S.-Mexico Gateway.* Research Report CTR 2932-3F, Center for Transportation Research. Austin, Texas, November 1995.

4 Picha, D.L., H.G. Hawkins, and K.N. Womack. *Motorist Understanding of Alternative Designs for Traffic Signs.* Research Report 1261-5F. Texas Transportation Institute, College Station, Texas, November 1995.

5. Hawkins, H.G., Jr., 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.

6. *Manual de Dispositivos Para el Control del Tránsito en Calles y Carreteras.* Secretaría de Comunicaciones y Transportes (SCT). México, D.F., April 1986.

7. *Uniform Traffic Control Devices for Canada (Metric Edition).* Roads and Transportation Association of Canada. Ottawa, Ontario, January 1976.

8. *INEGI - XI Censo General de Población y Vivienda, 1990.* The National Institute of Statistics, Geography and Information, Mexico, 1990.

APPENDIX A
RESULTS OF TEXAS DRIVER SURVEY

This appendix presents the results of the Texas driver survey administered to Texas drivers in Laredo, Texas at the Gateway to the Americas Bridge (Bridge #1) and at the Juarez-Lincoln Bridge (Bridge #2), in Hidalgo, Texas at the Hidalgo-Reynosa Bridge, and in Pharr, Texas at the Pharr-Reynosa Bridge. Researchers administered surveys to a total of 546 Texas drivers, with each driver answering an average of 26 questions on traffic control devices. The survey instrument contained comprehension-related questions for a total of 30 different traffic control devices or device scenarios, including seven regulatory signs, six warning signs, five pavement marking scenarios, seven signal displays, and five different Spanish-language alternative signs.

Table A-1 Second Year Texas Driver Survey Results for Regulatory Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	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	0.0	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	0.0	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 other is night (after dark) speed	No acceptable response	94.3	0.0	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	0.0	1.7	2.2	0.0	413
	What does this sign mean?	Right only or one way	No acceptable response	91.8	0.0	6.0	2.2	0.0	403

Table A-1 Second Year Texas Driver Survey Results for Regulatory Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	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	0.0	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	0.0	2.1	3.3	0.0	239

Table A-2 Second Year Texas Driver Survey Results for Warning Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	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	0.0	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	0.0	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?	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	0.0	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	0.0	27.5	46.4	0.0	153

Table A-2 Second Year Texas Driver Survey Results for Warning Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
	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?	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	0.0	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	0.0	14.2	11.5	0.0	226

Table A-3 Second Year Texas Driver Survey Results for Pavement Markings

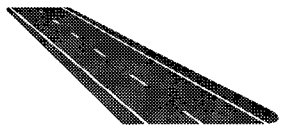
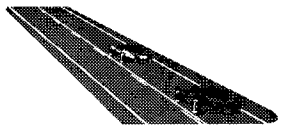
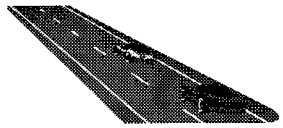
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
 Broken Yellow Centerline	Is this a one-way road or a two-way road?	Two-way road or cars going in both/opposing/ different directions	No acceptable response	83.2	0.0	16.3	0.5	0.0	417
 Broken Yellow Centerline	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	Is the blue car allowed to pass the red car?	No	No acceptable response	89.0	0.0	9.6	1.0	0.5	408
 Broken White Lane Line	Is this a one-way road or a two-way road?	One way or cars going in same direction	No acceptable response	48.3	0.0	48.7	2.1	0.8	236
 Broken White Lane Line	Is the blue car allowed to pass the red car?	Yes	No acceptable response	92.9	0.0	5.6	1.2	0.2	410

Table A-4 Second Year Texas Driver Survey Results for Traffic Signal Indications and Left Turn Signal Signs

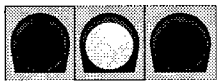
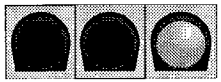
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
	What does the red in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Stop at intersection or do not cross intersection	No acceptable response	99.5	0.0	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	0.0	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	0.0	0.5	0.0	0.0	418

Table A-4 Second Year Texas Driver Survey Results for Traffic Signal Indications and Left Turn Signal Signs (continued)

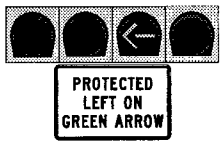
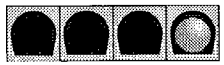
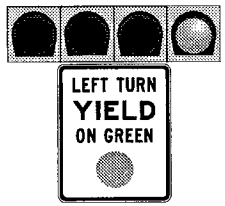
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?	No, the arrow tells me to go	I don't think so	85.9	0.0	4.1	9.2	0.7	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 A-5 Second Year Texas Driver Survey Results for Spanish-Legend Alternative Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	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	0.0	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 other is night (after dark) speed	No acceptable response	96.9	0.0	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	0.0	6.4	0.6	0.3	326

Table A-5 Second Year Texas Driver Survey Results for Spanish-Legend Alternative Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
	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	0.0	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	0.0	5.1	1.7	0.0	237

APPENDIX B
RESULTS OF TRUCK DRIVER SURVEY

This appendix presents the results of the truck driver survey administered to truck drivers in Laredo, Texas at the Laredo/Colombia Solidarity Bridge. Researchers administered surveys to 260 truck drivers at this location, with each driver answering questions related to the comprehension of nine different truck-related traffic signs. The signs related to truck speed, weight, clearance, or route designation. For seven of these nine signs, the researchers developed two or three alternative designs. The remaining two signs were an all Spanish-legend sign (to indirectly test each truck driver for literacy) and a truck and hazardous cargo route sign.

Table B-1 Second Year Truck Driver Survey Results - Set A

Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
A1		What does this sign mean?	Maximum speed/velocity/ limit **and** trucks **and** mph **and** day/night	One or more (but not all)	1.5		1.5	0.0	0.0	65
		Partial Correct	1.max speed limit 2.truck 3.miles per hour 4.day/night			98.5 13.8 10.8 40.0				
		If the primary answer is "*SPEED LIMIT*" without specifying "*TRUCKS*": a. What types of vehicles must obey this speed limit?	Trucks	No acceptable response	76.7	0.0	23.3	0.0	0.0	60
		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	96.6	0.0	3.4	0.0	0.0	59
		For all responses: c. Why are there two different numbers?	Day and night/dark	No acceptable response	79.7	0.0	10.2	10.2	0.0	59
		d. Does this sign apply to you?	Yes/sure	No acceptable response	97.6	0.0	0.0	0.0	2.4	42
A2		What does this sign mean?	Vehicles with hazardous cargo must follow sign **or** identifies a hazardous cargo route	No acceptable response	12.3	0.0	6.2	81.5	0.0	65
		a. What are you supposed to do if you see this sign on the road?	Follow this route if I am carrying hazardous cargo.	No acceptable response	60.0	0.0	40.0	0.0	0.0	5
		b. Can you give an example of a hazardous cargo?	List examples.							

Table B-1 Second Year Truck Driver Survey Results - Set A (continued)

Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
A3		What does this sign mean?	Bridge/structure **and** height of 13,6 **and** units	One or more (but not all)	9.2		7.7	9.2	0.0	65
		Partial Correct	1.bridge/structure 2.height of 13,6 3.units			81.5 13.8 0.0				
		For all responses: a. What is the height shown in this sign?	13 feet, 6 inches	No acceptable response	67.9	0.0	20.8	9.4	1.9	53
		If no units are given: b. What are the units of measurement?	Feet and inches	No acceptable responses	70.2	0.0	19.1	10.6	0.0	47
		For all responses: c. Is your truck higher, lower, or same as this sign?	H=higher L=lower S=same D=Don't Know E=Indeterminate		1.9 80.8 3.8			13.5	0.0	52
A4		What does this sign mean?	Maximum weight/limit **and** "ten tons"	Maximum weight/limit **or** "ten tons"	66.2		4.6	13.8	0.0	65
		Partial Correct	1.Maximum weight 2.ten tons			78.5 69.2				
		For all responses: a. What vehicles does this sign apply to?	Trucks	No acceptable response.	80.0	0.0	16.0	4.0	0.0	25
		b. Are these U.S. tons or Metric tonnes?	U.S. tons	No acceptable response.	32.7	0.0	57.7	9.6	0.0	52
		c. How much is a ton/tonne?	2000 lbs, 2,200 lbs, 1000 kgs, or 900 kgs.	No acceptable response.	66.7	0.0	15.4	17.9	0.0	39
		d. Does the weight limit refer to the entire vehicle, or each axle?	Entire vehicle.	No acceptable response.	65.4	0.0	30.8	1.9	1.9	52

Table B-1 Second Year Truck Driver Survey Results - Set A (continued)

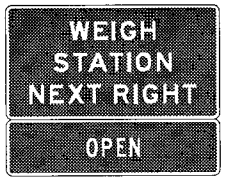
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
A5		What does this sign mean?	Weigh station open **and** trucks must stop to be weighed.	Weigh station open **or** trucks must stop to be weighed.	12.1	24.2	9.1	54.5	0.0	66
		If "*BASCULA*" is not used as a response: a. What is a weigh station?	Place where trucks are weighed	No acceptable response.	100.0	0.0	0.0	0.0	0.0	4
		For all responses: What vehicles must go through the weigh station?	Trucks	No acceptable response.	96.7	0.0	3.3	0.0	0.0	30
A6		What does this sign mean?	Weight limit **and** bridge	Weight limit **or** bridge	12.3		23.1	38.5	0.0	65
		Partial Correct	1.Weight limit 2.bridge			12.3 38.5				
		If the answer indicates a "*BRIDGE AHEAD WITH A WEIGHT LIMIT*": a. What would you do if you saw this sign on the road?	Look for posted weight limit **or** check/compare truck limit with posted weight limit	Stop, turn around, or find another road (*without further explanation*)	25.0	12.5	62.5	0.0	0.0	16
A7		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	12.5	9.4	1.6	76.6	0.0	64
		For all responses: a. What are you supposed to do if you see this sign on the road you are on?	Stay off this road if I am carrying hazardous cargo (or similar variation)	No acceptable response.	80.0	0.0	20.0	0.0	0.0	5

Table B-1 Second Year Truck Driver Survey Results - Set A (continued)

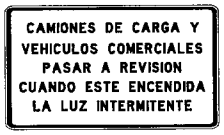
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
A8		What does this sign mean?		Literate = Partially Literate = Illiterate = Indeterminate =	82.0 13.7 3.9 0.0				0.4	255
A9		What does this sign & phrase mean?	Truck route **or** road for trucks (or similar variation)	No acceptable response.	96.9	0.0	3.1	0.0	0.0	64

Table B-2 Second Year Truck Driver Survey Results - Set B

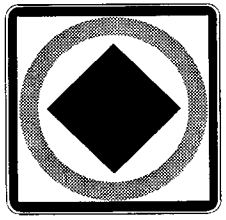
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
B1		What does this sign mean?	Maximum speed/velocity/ limit **and** trucks **and** mph **and** day/night	One or more (but not all)	6.1		0.0	0.0	0.0	66
		Partial Correct	1.max speed limit 2.truck 3.miles per hour 4.day/night			100.0 22.7 19.7 16.7				
		If the primary answer is "*SPEED LIMIT*" without specifying "*TRUCKS*": a. What types of vehicles must obey this speed limit?	Trucks	No acceptable response	84.4	0.0	12.5	0.0	3.1	64
		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	94.9	0.0	3.4	1.7	0.0	59
		For all responses: c. Why are there two different numbers?	Day and night/dark	No acceptable response	81.7	0.0	16.7	1.7	0.0	60
		d. Does this sign apply to you?	Yes/sure	No acceptable response	97.9	0.0	0.0	0.0	2.1	48
B2		What does this sign mean?	Vehicles with hazardous cargo must follow sign **or** identifies a hazardous cargo route	No acceptable response	3.0	0.0	4.5	92.4	0.0	66
		a. What are you supposed to do if you see this sign on the road?	Follow this route if I am carrying hazardous cargo.	No acceptable response	100.0	0.0	0.0	0.0	0.0	1
		b. Can you give an example of a hazardous cargo?	List examples.							

Table B-2 Second Year Truck Driver Survey Results - Set B (continued)

Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
B3		What does this sign mean?	Bridge/structure **and** height of 4.2/4.20 **and** units	One or more (but not all)	21.2		7.6	3.0	0.0	66
		Partial Correct	1.bridge/structure 2.height of 13,6 3.units			89.4 30.3 24.2				
		For all responses: a. What is the height shown in this sign?	4.2 meters **or** 4 meters,20 centimeters	No acceptable response	98.1	0.0	0.0	1.9	0.0	53
		If no units are given: b. What are the units of measurement?	Meters	No acceptable responses	91.8	0.0	4.1	4.1	0.0	49
		For all responses: c. Is your truck higher, lower, or same as this sign?		Higher = Lower = Same = Indeterminate =	6.9 81.0 8.6 0.0			1.7	1.7	58
B4		What does this sign mean?	Maximum weight/limit **and** "ten tonnes"	Maximum weight/limit **or** "ten tonnes"	22.7		22.7	54.5	0.0	66
		Partial Correct	1.Maximum weight 2.ten tonnes			22.7 22.7				
		For all responses: a. What vehicles does this sign apply to?	Trucks	No acceptable response.	57.1	0.0	28.6	14.3	0.0	7
		b. Are these U.S. tons or Metric tonnes?	Metric tonnes	No acceptable response.	50.0	0..0	50.0	0.0	0.0	14
		c. How much is a ton/tonne?	2000 lbs, 2,200 lbs, 1000 kgs, or 900 kgs.	No acceptable response.	80.0	0.0	10.0	10.0	0.0	10
		d. Does the weight limit refer to the entire vehicle, or each axle?	Entire vehicle.	No acceptable response.	84.6	0.0	15.4	0.0	0.0	13

Table B-2 Second Year Truck Driver Survey Results - Set B (continued)

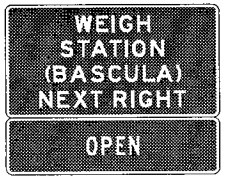
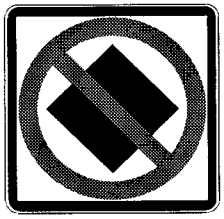
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
B5		What does this sign mean?	Weigh station open **and** trucks must stop to be weighed.	Weigh station open **or** trucks must stop to be weighed.	33.3	65.2	0.0	1.5	0.0	66
		If "*BASCULA*" is not used as a response: a. What is a weigh station?	Place where trucks are weighed	No acceptable response.	100.0	0.0	0.0	0.0	0.0	2
		For all responses: What vehicles must go through the weigh station?	Trucks	No acceptable response.	83.1	0.0	9.2	7.7	0.0	65
B6		What does this sign mean?	Weight limit **and** bridge	Weight limit **or** bridge	87.4		5.5	0.8	0.0	127
		Partial Correct	1.Weight limit 2.bridge			91.3 89.8				
		If the answer indicates a "*BRIDGE AHEAD WITH A WEIGHT LIMIT*": a. What would you do if you saw this sign on the road?	Look for posted weight limit **or** check/compare truck limit with posted weight limit	Stop, turn around, or find another road (*without further explanation*)	62.5	25.8	7.5	5.0	0.0	120
B7		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	1.5	29.2	3.1	66.2	0.0	65
		For all responses: a. What are you supposed to do if you see this sign on the road you are on?	Stay off this road if I am carrying hazardous cargo (or similar variation)	No acceptable response.	0.0	0.0	100.0	0.0	0.0	1

Table B-2 Second Year Truck Driver Survey Results - Set B (continued)

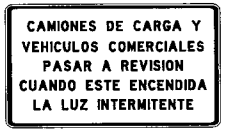
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
B8		What does this sign mean?		Literate = Partially Literate = Illiterate = Indeterminate =	82.0 13.7 3.9 0.0				0.4	255
B9		What does this sign & phrase mean?	No truck on this route (or similar variation)	No acceptable response.	95.4	0.0	4.6	0.0	0.0	65

Table B-3 Second Year Truck Driver Survey Results - Set C

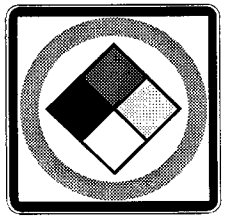
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
C1		What does this sign mean?	Maximum speed/velocity/ limit **and** trucks **and** mph **and** day/night	One or more (but not all)	4.5		1.5	0.0	0.0	66
		Partial Correct	1.max speed limit 2.truck 3.miles per hour 4.day/night			98.5 19.7 13.6 31.8				
		If the primary answer is "*SPEED LIMIT*" without specifying "*TRUCKS*": a. What types of vehicles must obey this speed limit?	Trucks	No acceptable response	91.9	0.0	8.1	0.0	0.0	62
		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	98.4	0.0	0.0	1.6	0.0	61
		For all responses: c. Why are there two different numbers?	Day and night/dark	No acceptable response	90.0	0.0	10.0	0.0	0.0	60
		d. Does this sign apply to you?	Yes/sure	No acceptable response	100.0	0.0	0.0	0.0	0.0	49
C2		What does this sign mean?	Vehicles with hazardous cargo must follow sign **or** identifies a hazardous cargo route	No acceptable response	29.9	0.0	9.4	60.6	0.8	127
		a. What are you supposed to do if you see this sign on the road?	Follow this route if I am carrying hazardous cargo.	No acceptable response	39.1	0.0	47.8	13.0	0.0	23
		b. Can you give an example of a hazardous cargo?	List examples.							

Table B-3 Second Year Truck Driver Survey Results - Set C (continued)

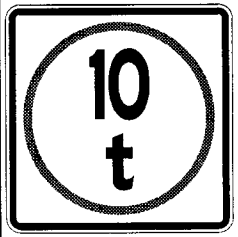
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
C3		What does this sign mean?	Bridge/structure **and** height of 4.2/4.20 **and** units	One or more (but not all)	18.5		1.5	7.7	0.0	65
		Partial Correct	1.bridge/structure 2.height of 13,6 3.units			87.7 26.2 21.5				
		For all responses: a. What is the height shown in this sign?	4.2 meters **or** 4 meters,20 centimeters	No acceptable response	76.8	0.0	19.6	3.6	0.0	56
		If no units are given: b. What are the units of measurement?	Meters	No acceptable responses	86.7	0.0	8.9	4.4	0.0	45
		For all responses: c. Is your truck higher, lower, or same as this sign?		Higher = Lower = Same = Indeterminate =						
C4		What does this sign mean?	Maximum weight/limit **and** "ten tonnes"	Maximum weight/limit **or** "ten tonnes"	3.1		24.6	67.7	0.0	65
		Partial Correct	1.Maximum weight 2.ten tonnes			3.1 7.7				
		For all responses: a. What vehicles does this sign apply to?	Trucks	No acceptable response.						
		b. Are these U.S. tons or Metric tonnes?	Metric tonnes	No acceptable response.	60.0	0.0	40.0	0.0	0.0	5
		c. How much is a ton/tonne?	2000 lbs, 2,200 lbs, 1000 kgs, or 900 kgs.	No acceptable response.	50.0	0.0	25.0	0.0	25.0	4
		d. Does the weight limit refer to the entire vehicle, or each axle?	Entire vehicle.	No acceptable response.	75.0	0.0	25.0	0.0	0.0	4

Table B-3 Second Year Truck Driver Survey Results - Set C (continued)

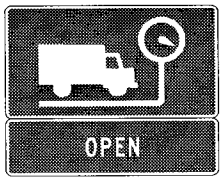
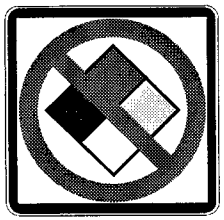
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
C5		What does this sign mean?	Weigh station open **and** trucks must stop to be weighed.	Weigh station open **or** trucks must stop to be weighed.	14.2	28.3	19.7	37.8	0.0	127
		If "*BASCULA*" is not used as a response: a. What is a weigh station?	Place where trucks are weighed	No acceptable response.	100.0	0.0	0.0	0.0	0.0	5
		For all responses: What vehicles must go through the weigh station?	Trucks	No acceptable response.	83.3	0.0	16.7	0.0	0.0	66
C6		What does this sign mean?	Weight limit **and** bridge	Weight limit **or** bridge	70.8		13.8	6.2	0.0	65
		Partial Correct	1.Weight limit 2.bridge			73.9 77.0				
		If the answer indicates a "*BRIDGE AHEAD WITH A WEIGHT LIMIT*": a. What would you do if you saw this sign on the road?	Look for posted weight limit **or** check/compare truck limit with posted weight limit	Stop, turn around, or find another road (*without further explanation*)	33.3	44.4	18.5	1.9	1.9	54
C7		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	24.4	11.4	4.1	60.2	0.0	123
		For all responses: a. What are you supposed to do if you see this sign on the road you are on?	Stay off this road if I am carrying hazardous cargo (or similar variation)	No acceptable response.	83.3	0.0	16.7	0.0	0.0	12

Table B-3 Second Year Truck Driver Survey Results - Set C (continued)

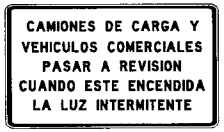
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
C8		What does this sign mean?		Literate = Partially Literate = Illiterate = Indeterminate =	82.0 13.7 3.9 0.0				0.4	255
C9		What does this sign & phrase mean?	Vehicles with hazardous cargo must follow sign **or** identifies a hazardous cargo route	No acceptable response.	92.2	0.0	6.3	1.6	0.0	64

Table B-4 Second Year Truck Driver Survey Results - Set D

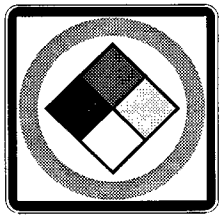
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
D1		What does this sign mean?	Maximum speed/velocity/ limit **and** trucks **and** mph **and** day/night	One or more (but not all)	0.0		0.0	0.0	0.0	62
		Partial Correct	1.max speed limit 2.truck 3.miles per hour 4.day/night			100.0 3.2 14.6 50.0				
		If the primary answer is "*SPEED LIMIT*" without specifying "*TRUCKS*": a. What types of vehicles must obey this speed limit?	Trucks	No acceptable response	75.4	0.0	22.8	1.8	0.0	57
		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	94.4	0.0	1.9	3.7	0.0	54
		For all responses: c. Why are there two different numbers?	Day and night/dark	No acceptable response	87.7	0.0	7.0	5.3	0.0	57
		d. Does this sign apply to you?	Yes/sure	No acceptable response	100.0	0.0	0.0	0.0	0.0	42
D2		What does this sign mean?	Vehicles with hazardous cargo must follow sign **or** identifies a hazardous cargo route	No acceptable response	29.9	0.0	9.4	60.6	0.8	127
		a. What are you supposed to do if you see this sign on the road?	Follow this route if I am carrying hazardous cargo.	No acceptable response	39.1	0.0	47.8	13.0	0.0	23
		b. Can you give an example of a hazardous cargo?	List examples.							

Table B-4 Second Year Truck Driver Survey Results - Set D (continued)

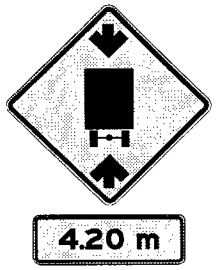
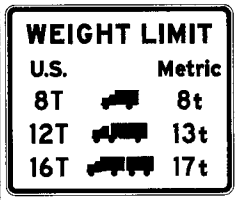
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
D3		What does this sign mean?	Bridge/structure **and** height of 4.2/4.20 **and** units	One or more (but not all)	9.7		11.3	3.2	1.6	62
		Partial Correct	1.bridge/structure 2.height of 13,6 3.units			80.6 19.4 12.9				
		For all responses: a. What is the height shown in this sign?	4.2 meters **or** 4 meters,20 centimeters	No acceptable response	100.0	0.0	0.0	0.0	0.0	51
		If no units are given: b. What are the units of measurement?	Meters	No acceptable responses	100.0	0.0	0.0	0.0	0.0	44
		For all responses: c. Is your truck higher, lower, or same as this sign?		Higher = Lower = Same = Indeterminate =	0.0 75.5 20.8 0.0			3.8	0.0	53
D4		What does this sign mean?	Maximum weight/weight limit **and** different trucks	Maximum weight **or** weight limit	14.5		24.2	25.8	0.0	62
		Partial Correct	1.Maximum weight 2.ten tons			50.0 0.0				
		For all responses: a. What vehicles does this sign apply to?	Trucks	No acceptable response.	100.0	0.0	0.0	0.0	0.0	11
		b. What is the difference between the weights shown?	One column is U.S. units **and** the other is Metric.	One column is U.S. **or** one column is Metric.	62.1	0.0	10.3	24.1	3.4	29
		c. How much is a U.S. ton? c. How much is a Metric tonne	2000 lbs, 2,200 lbs, 1000 kgs, or 900 kgs.	No acceptable response.	27.8 61.1	0.0 0.0	27.8 16.7	44.4 22.2	0.0 0.0	18 18
		d. Does the weight limit refer to the entire vehicle, or each axle?	Entire vehicle.	No acceptable response.	32.1	0.0	64.3	0.0	3.6	28

Table B-4 Second Year Truck Driver Survey Results - Set D (continued)

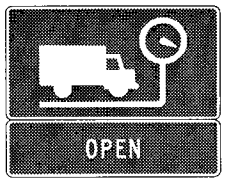
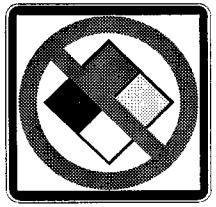
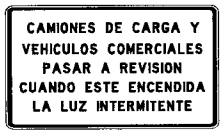
Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
D5		What does this sign mean?	Weigh station open **and** trucks must stop to be weighed.	Weigh station open **or** trucks must stop to be weighed.	14.2	28.3	19.7	37.8	0.0	127
		If "*BASCULA*" is not used as a response: a. What is a weigh station?	Place where trucks are weighed	No acceptable response.	100.0	0.0	0.0	0.0	0.0	5
		For all responses: What vehicles must go through the weigh station?	Trucks	No acceptable response.	83.3	0.0	16.7	0.0	0.0	66
D6		What does this sign mean?	Weight limit **and** bridge	Weight limit **or** bridge	87.4		5.5	0.8	0.0	127
		Partial Correct	1.Weight limit 2.bridge			91.3 89.8				
		If the answer indicates a "*BRIDGE AHEAD WITH A WEIGHT LIMIT*": a. What would you do if you saw this sign on the road?	Look for posted weight limit **or** check/compare truck limit with posted weight limit	Stop, turn around, or find another road (*without further explanation*)	62.5	25.8	7.5	5.0	0.0	120
D7		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	24.4	11.4	4.1	60.2	0.0	123
		For all responses: a. What are you supposed to do if you see this sign on the road you are on	Stay off this road if I am carrying hazardous cargo (or similar variation)	No acceptable response.	83.3	0.0	16.7	0.0	0.0	12

Table B-4 Second Year Truck Driver Survey Results - Set D (continued)

Ques No.	Device	English Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	In-correct	Not Sure	Un-known	Sample Size
D8		What does this sign mean?		Literate = Partially Literate = Illiterate = Indeterminate =	82.0 13.7 3.9 0.0				0.4	255
D9		What does this sign & phrase mean?	Vehicles with hazardous cargo are not allowed on this road **or** hazardous cargo prohibited **or** no hazardous cargo	No acceptable response.	93.1	0.0	5.2	1.7	0.0	58