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16. Abstract

The Texas-Mexico border area possesses many unique characteristics that could potentially reduce the effectiveness of traffic control devices used in these areas. This report describes the results from the first year of a three-year research project on the use of traffic control devices in Texas border areas. The first year was devoted to information gathering and an assessment of traffic control device understanding among drivers entering Texas from Mexico. Key first-year tasks included gathering information from pertinent literature and telephone interviews and conducting surveys of driver comprehension of existing traffic control devices. The surveys used a flashcard format and were administered to drivers on international bridges going from Mexico to Texas. In general, the results indicate that Mexican drivers understand most of the traffic control devices included in the survey. Devices that were found to exhibit a potential for improvement include: the Yield sign, the use of yellow in pavement markings to distinguish two-way traffic, hazardous cargo signing, some aspects of truck weight signs, the difference between yellow and orange signs, understanding of specific signs, and the proper driving response to school buses.

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ASSESSMENT OF MEXICAN DRIVER UNDERSTANDING OF EXISTING TRAFFIC CONTROL DEVICES USED IN TEXAS

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Sponsored by the
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IMPLEMENTATION STATEMENT

The part of Texas along the Mexico border exhibits many unique characteristics, including many that are related to the manner in which drivers operate on the highway system. In particular, the ability to provide border area drivers with traffic control devices that they can understand and respond to is an essential part of providing a safe and efficient transportation system. This research project was initiated to evaluate the effectiveness of existing traffic control devices used in border areas and to develop improvements for those devices. This report describes the findings from the first year of the project. These findings can be used on an interim basis to make minor improvements in border area traffic control devices.

DISCLAIMER

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

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At the initiation of this project, TxDOT formed a panel of Project Advisors to provide guidance in the development and conduct of the research activities and review project deliverables. The Project Advisors were able to provide the researchers with valuable insights related to the manner in which border area drivers respond to traffic control devices. They also served as a valuable resource for obtaining information related to the research activities. The research team met with the Project Advisors on several occasions, and the assistance and comments received from them were instrumental in conducting the project activities. The researchers would like to acknowledge the following Project Advisors for their time, efforts, and contributions:

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

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- Carlos Chavez, El Paso District, Texas Department of Transportation
- Vic Garcia, International Relations Office, Texas Department of Transportation
- Jesus Leal, Pharr District, Texas Department of Transportation
- Ted Ozuna, San Antonio District, Texas Department of Transportation
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SUMMARY

The areas of Texas along the Mexican border have always possessed many unique characteristics that make these areas distinct from other areas of Texas. The Hispanic influence and the predominance of Spanish as the spoken language are the most significant factors that make these areas so different from the rest of the state. Not only is there a predominant Hispanic presence among Texas border area residents, the number of tourists and truck drivers who speak only Spanish is steadily increasing due to the expected increases in international traffic from the free-trade zone and the North American Free Trade Agreement (NAFTA). As a result of these and other factors, there is concern that traffic control devices used on highways and streets in the Texas border areas may not adequately meet the information needs of border area drivers. In particular, there is a concern that signs, many of which were originally designed for English-speaking drivers, may not be well-suited to border drivers, many of whom speak only Spanish, or very limited English. Some of the major factors that might affect the effectiveness of traffic control devices in border areas are:

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

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

This report documents the activities and findings of the first year of the three-year research project. The first year was devoted to problem identification and included the following activities:

- **Identify target population** - In order to focus the research efforts on a manageable portion of the border driver population, the researchers, in combination with the Project Advisors, determined that the research should address Mexican drivers entering Texas from Mexico, driving either automobiles or commercial trucks. Throughout this report, they are referred to as "Mexican drivers" with the intent that they are residents of Mexico driving a vehicle in a Texas border area.

- **Gather pertinent information** - The first part of the project was devoted to gathering available information about the border areas and pertinent research. Activities and findings are described in Chapter II.
  - *Review available literature* - Researchers reviewed the literature that addressed various issues of concern to border area traffic control devices. Specific literature includes traffic control device documents and evaluations of driver comprehension in border areas.
  - *Contact U.S. and Mexican transportation professionals/officials* - Telephone interviews were conducted of various individuals associated with transportation issues in the border areas.
  - *Coordinate with NAFTA Working Group on Traffic Control Devices* - Representatives from Canada, Mexico, and the United States have created a working group to address the key traffic control device issues related to implementation of NAFTA.
- **Conduct critical incident survey** - A critical incident survey was prepared and administered to identify locations where Mexican drivers were having navigational difficulties. Activities and findings are described in Chapter III. For various reasons described in Chapter III, the critical incident survey did not provide information that could be used in the first-year problem identification effort.
- **Assess driver comprehension of existing traffic control devices** - A driver comprehension survey was developed and administered to determine whether Mexican drivers were having difficulty understanding existing traffic control devices. Survey development, administration, and results are described in Chapter III. In general, the survey results indicate that the existing system of traffic control devices used in the Texas border area functions well among the target population.
- **Develop initial findings** - The researchers used the results of the first-year research activities to develop the initial project findings. These findings are described in Chapter IV. Potential areas for improvement actions include:
  - Stopping laws for school buses,
  - Handout information for Mexican truck drivers and/or Mexican tourists,
  - Bilingual signing for specific applications,
  - Explanatory signing for specific applications, and
  - Additional evaluations of speed limit signing.

CHAPTER I
INTRODUCTION

The areas of Texas along the Mexican border have always possessed many unique characteristics that make these areas distinct from other areas of Texas. The Hispanic influence and the predominance of Spanish as the spoken language are the most significant factors that make these areas so different from the rest of the state. Not only is there a predominant Hispanic presence among Texas border area residents, the number of tourists and truck drivers who speak only Spanish is steadily increasing with the opening of the Texas/Mexico border. As a result of these and other factors, there is concern that traffic control devices used on highways and streets in the Texas border areas may not adequately meet the information needs of border area drivers.

Although the border areas have possessed a strong Hispanic influence for many years, the expected increases in international traffic due to the free-trade zone and the North American Free Trade Agreement (NAFTA) have focused additional concern on the existing system of traffic control devices. In particular, there is a concern that signs, many of which were originally designed for English-speaking drivers, may not be well-suited to border drivers, many of whom speak only Spanish, or very limited English.

KEY ISSUES

Some of the key unique issues related to border area traffic control devices include: the use of two languages in border areas, the presence of two systems of measurement (International System [S.I.] and United States [U.S.] Customary), differences in the traffic control devices used in Mexico and Texas, and cultural differences between Mexican and U.S. drivers. For several years, the Texas Department of Transportation (TxDOT) has been concerned about these issues and the ability of traffic control devices to meet the needs of border area drivers. Unfortunately, the effectiveness of traffic control devices in meeting the information needs of border area drivers is a largely undocumented and unquantified issue. Therefore, TxDOT sponsored this research project, being conducted by the Texas Transportation Institute (TTI), to investigate the effectiveness of border area traffic control devices and to develop appropriate recommendations for improving the effectiveness of these devices. The following paragraphs summarize some of the key points associated with these issues. They are discussed in greater detail in Chapter II (Background).

Language

One of the expressions of this continuity is the use of the Spanish language. The Mexican border cities (MBCs) are predominantly monolingual, and the Spanish-English bilingualism that one might expect to observe is purely specific or transitional. The use of English is generally related to the job site or other situations in which a monolingual English is present. On the U.S.-Mexico border, as in many countries in the world, there is a tendency to learn English in high school, and its use is characterized by an urban or industrial context. Its use is more frequent, although not exclusive, among middle and upper class individuals.

Units of Measurement

The researchers identified as a key issue the ability of Mexican drivers to understand the use of U.S. Customary units of measurements in traffic control devices. The most significant highway-related measurements in traffic control devices that are affected by the use of measurements, both in S.I. and U.S. Customary units, include:

- Speed limit signs;
- Weight limit signs;
- Distance signs;
- Vertical clearance signs;
- Mileposts;
- Roadway/bridge width signs; and
- Supplemental distance signs.

Compatibility of Traffic Control Devices

There are both many similarities and significant differences in the traffic control device systems used in the United States and Mexico. The basic color and shape principles are similar in the two countries, except for the use of a red circle in Mexican regulatory signs. The major differences that may cause difficulties include the units of measurement, the design of the speed limit sign, the color of pavement markings, the design of permissive signs, signs for hazardous cargo freight, and the use of word message signs.

Cultural Differences

From a sociocultural perspective, North American border cities have noticeable Mexican characteristics, while from an economic perspective, MBCs exhibit mostly North American characteristics. MBCs are distinguished by the presence of the assembly industry. In spite of the gradual transformation of the twin cities, the Mexican presence and ethnolinguistic continuity with Mexico are still obvious.

NAFTA WORKING GROUP ON TRAFFIC CONTROL DEVICES

The *Working Group on Traffic Control Devices* is one of five working groups of the Land Transportation Standards Subcommittee associated with NAFTA. The group has met three times, with additional meetings scheduled for the near future. The group has compared the use of traffic control devices in Canada, U.S., and Mexico and determined that "*commercial and private drivers will experience only minimal inconvenience, due to the differences in traffic control devices, when driving on one of the other two countries' highways*" (unpublished correspondence). The group identified eight areas where differences in traffic control devices may be significant:

- Metric units;
- Speed limit signs;
- Permissive signs;
- Word message signs;

- Color of pavement markings;
- Hazardous cargo signs;
- Symbol signs; and
- Traffic control devices for construction areas.

The activities of the working group are described in more detail in Chapter II (Background Information).

RESEARCH APPROACH

At present, there are no formal guidelines to help TxDOT personnel determine how best to use signs and other traffic control devices to meet the information needs of border area drivers. The results of this research will provide TxDOT with the guidance to improve the use and effectiveness of traffic control devices in the border areas of Texas. The guidelines will lead to more effective methods of meeting the unique information needs of border area drivers, thereby reducing driver uncertainty and improving the overall safety of the Texas highway system. Improving the ability of Spanish speaking drivers to respond to traffic control devices will lead to a friendlier transportation system and encourage the economic development of commercial and tourist facilities in border areas. Improved traffic control devices would also improve TxDOT's ability to restrict overweight and overheight commercial vehicles to highway facilities and service locations that can safely accommodate them. In general, the research results will provide TxDOT with the tools to meet the unique information needs of border area drivers and provide a safer and more efficient transportation system.

The researchers will address the goal and objectives of this three-year research project through a three-phase work plan. The goal, objectives, and phases are listed below. These three phases correspond to the primary areas of emphasis for the project.

- **Research Goal:**
  - Identify the information needs of drivers in Texas border areas, determine how traffic control devices can be improved to better convey the needed information to border area drivers, and develop recommendations for the use of the improved devices.
- **Research 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.
- Document the research project activities in interim and final reports.

- **Research Phases:**
  - Phase I - identification of information needs and deficiencies,
  - Phase II - evaluation of existing and proposed traffic control devices, and
  - Phase III - development and implementation of recommendations.

TARGET POPULATION

The drivers in the Texas border areas present a wide range of driver characteristics that can impact the effectiveness of traffic control devices in the border areas. Examples of these characteristics include: place of residence (Texas border, Texas non-border, Mexico), type of vehicle (private automobile, commercial truck), and language capabilities (English, Spanish, bilingual). Addressing all of these driver characteristics would have diluted the research resources. Therefore, the researchers, in combination with the Project Advisors, determined that the research should focus on Mexican drivers coming into Texas driving either automobiles or commercial trucks.

FIRST YEAR PROJECT ACTIVITIES

Because the effectiveness of traffic control devices in border areas has not been sufficiently evaluated in the past, the first year of the project was devoted to problem identification. The first-year activities included review of related information, interviews of transportation professionals, driver surveys, and identification of major issues of concern. The key first-year activities are briefly described below. Where appropriate, these descriptions identify the portion of this report that provides the results of the activity.

- **Gather pertinent information** - Specific efforts are listed below. Activities and findings are described in Chapter II.
  - *Review available literature* - Researchers reviewed the literature that addressed various issues of concern to border area traffic control devices. Specific literature includes traffic control device documents and evaluations of driver comprehension in border areas.
  - *Contact U.S. and Mexican transportation professionals/officials* - Telephone interviews were conducted of various individuals associated with transportation issues in the border areas.
  - *Coordinate with NAFTA Working Group on Traffic Control Devices* - Representatives from Canada, Mexico, and the United States have created a working group to address the key traffic control device issues related to implementation of NAFTA.

- **Conduct critical incident survey** - A critical incident survey was prepared and administered to identify locations where Mexican drivers were having navigational difficulties. Activities and findings are described in Chapter III.
- **Assess driver comprehension of existing traffic control devices** - A driver comprehension survey was developed and administered to determine whether Mexican drivers were having difficulty understanding existing traffic control devices. Activities and findings are also described in Chapter III.
- **Develop initial findings** - The researchers used the results of the first-year research activities to develop the initial project findings. These findings are described in Chapter IV.

CHAPTER II
BACKGROUND INFORMATION

The initial effort of the first-year of the research project was to gather information from a variety of resources in order to identify difficulties that Mexican drivers might have with the traffic control devices used in Texas border areas. The researchers undertook several different information gathering activities, including:

- identifying pertinent language and cultural characteristics of Mexican drivers;
- comparing pertinent principles for traffic control devices in the U.S. and Mexico;
- coordinating activities with the NAFTA Working Group on Traffic Control Devices;
- identifying the findings of previous research; and
- conducting telephone interviews of transportation professionals.

LANGUAGE AND CULTURAL ISSUES

Language differences contribute to the difficulty of relying upon traffic control devices to convey important information to drivers; moreover, the language barrier is not exclusive to Mexican drivers. Many residents of Texas border areas speak Spanish as their primary, or only, language. Therefore, it is appropriate to consider alternative methods of using traffic control devices to communicate with non-English speaking drivers. TxDOT has been aware of this fact for many years. In fact, the 1954 Texas MUTCD (1) included the STOP sign (black-on-yellow color scheme, shown in Figure II-1), for use in districts having a large "Latin-American population."

Figure II-1. Early Texas Stop Sign

The influence of the Mexican culture in the Texas border areas is evident in the region's language, religion, customs, and traditions. The region's unique characteristics are fostered by two salient factors: the large population of Mexican Americans residing in the Rio Grande Valley and the region's close proximity to Mexico. As a result of its geographic setting and its historical relationship with Mexico, the culture, politics, socioeconomics, and demography of Texas and Mexico combine to form a population distinct from those found in other areas of Texas (2).

Linguistics

These distinguishable traits are manifested in several forms. Language, for example, is a clear indicator of the bilingual, bicultural climate in the Rio Grande Valley. Across the six counties of the Lower Rio Grande Valley (Cameron, Hidalgo, Jim Hogg, Starr, Willacy, and Zapata), 80 percent of the inhabitants of this region speak Spanish (3). This attribute is strongly linked to the region's close proximity to Mexico and the continuous flow of immigrants—both legal and illegal. *The Texas Border Fact Book* further indicated that three counties, Cameron, Hidalgo, and Starr, have the highest ratio of foreign to native-born residents. Approximately one in four residents of Cameron, one in three residents of Hidalgo, and one in two residents of Starr County are foreign born (3).

The ethnic composition of the Rio Grande Valley has led to the adaptation of a regional dialect commonly referred to as "Tex-Mex," Spanglish, or *caló*. This dialect resulted from the need to conduct business and daily activities in a bilingual environment. It incorporates both English and Spanish words and produces a variation of two tongues. These words are hybrids which can usually be deciphered by English and Spanish monolinguals who live in the border area. Furthermore, this South Texas vocabulary is integrated into daily speech patterns through code-switching (the rapid shifts between two languages during a conversation). Common "Tex-Mex" phrases include words such as *carpeta* for carpet, *cookiar* for cook, *wachar* for watch, and *parkear* for park.

A recently published book describes the linguistic aspects of the United States/Mexico border area. *Open Signs: Language and Society on the United States-Mexico Border* (4) provides important insights into the cultural and linguistic sensitivities on both sides of the border. According to the authors, people of Hispanic ancestry typically are bilingual upon the second generation after immigrating to the United States side of the border, and speak only English by the fourth generation. This is true only for those immigrants and their descendants who move beyond the American border communities (ABCs) into areas further interior, such as San Antonio. People of Hispanic heritage who reside in ABCs usually remain bilingual. Furthermore, residents on the opposite side of the border in Mexican border communities (MBCs) are bilingual only to the extent that they speak limited English to American tourists who do not speak Spanish. When they are in any other situations, they always speak Spanish. This is referred to as *transitional bilingualism*. There would be a loss of the transitional bilingualism if North American tourists no longer visited the borders and certain industries ceased to exist. In other words, the Mexicans would not use English at all and would transition back to only the Spanish language.

North American Free Trade Agreement

With the passage of the North American Free Trade Agreement (NAFTA), traffic flow along the U.S.-Mexico border has increased steadily. Commercial crossings along U.S.-Mexico points of entry account for an estimated 1.8 million of the annual border crossings in 1995; this number is expected to increase to 12 million by the year 2000 (5).

Although frequent crossings are made by Mexican trucking companies, many of those companies traveling in the U.S. remain within a close distance to the U.S.-Mexico border. An estimated 90 percent of the Mexican trucking companies operating in Hidalgo County (a Texas border county) only travel to the boundaries of the Foreign Trade Zone before returning to Mexico (6).

Some U.S. consumer groups and trucking officials argue that U.S. trucking companies are required to meet higher operating standards than their Mexican counterparts. They stress that safety for Valley residents is compromised when unregulated Mexican companies are allowed to operate along the border.

In the Rio Grande Valley, several arrangements between U.S. and Mexican cities have facilitated the movement of commercial traffic. The Paired Cities Agreement and the 1993 Tamaulipas Understanding have exempted truckers driving in certain sections of the Rio Grande Valley from adhering to state licensing rules.

General Findings from Literature

The following findings were identified to be of importance to Mexican trucking companies who operate in the United States.

- **Familiarity of Traffic Signs**: Due to limited fluency in the English language, many Mexican truck drivers have limited familiarity with traffic signs. They can recognize and interpret commonly seen traffic symbols; however, they still encounter some difficulty in interpreting certain types of traffic signs with words or phrases.
- **System of Measurement**: Of the truck drivers polled, many agreed that the S.I. system is very important to their on-the-job performance. Unlike the language barrier, the U.S. Customary System poses a greater degree of difficulty. This is encountered in instances where the height of an overpass is expressed in yards and feet. For many drivers, the conversion from the U.S. Customary System to the International System is difficult in these situations.
- **Trucking Rules and Regulations**: Mexican truck drivers continue to remain uninformed on rules and regulations that affect their profession. Their knowledge in the areas of personal safety, commercial vehicle safety, and weight restrictions is limited.

PRINCIPLES FOR TRAFFIC CONTROL DEVICES

There are two basic systems of traffic control devices used in the world today: the American system and the European system. The American system is the older of the two and is primarily used in North America, South America, and Australia. The European system is used in most other countries. Some countries, such as Mexico, utilize a combination of both methods. Table II-1 describes some of the key differences between the two signing systems.

Table II-1. Comparison of American and European Signing Systems

System	Communication Methods	Regulatory Signs	Warning Signs	Freeway Guide Signs	Pavement Markings
American	Words and Symbols	Black on white Vertical rectangle	Black on yellow Diamond	White on green Horizontal rectangle	Yellow and white
European	Symbols	Black on white Red border Circle	Black on white Red border Triangle	Various colors Horizontal rectangle	Primarily all white

Traffic Control Devices in Texas

The *Texas Manual on Uniform Traffic Control Devices* (TxMUTCD) (7) establishes the basic principles for traffic control devices used in Texas. It is based on the national MUTCD (8). The national MUTCD was first published in 1935 and has undergone numerous revisions during the ensuing 60 years. The first Texas MUTCD was published in 1954, although there were earlier documents that provided some limited guidance for the use of traffic control devices.

In the United States, the early signs were primarily word oriented, with English being the language of choice. However, in the 1970s, the MUTCD began a shift toward internationality with the introduction of many symbol signs. The wider use of symbols, while potentially increasing the ability of international drivers to understand the signs, has created a concern of reduced understanding among native drivers.

Texas has had a large Hispanic presence in the border areas for many years. One of the earliest instances of this recognition, as it relates to traffic control devices, is a special STOP sign that was described in the 1954 Texas MUTCD (1). This STOP sign, illustrated in Figure II-1 (see page 1), contained both English and Spanish words. It was also a black-on-yellow sign. The MUTCD indicated that it was for use in districts having a large "Latin-American population."

In 1971, the Texas Highway Department (THD, a predecessor of TxDOT), issued a letter to districts that described a day/night Mexican metric speed limit sign assembly for use on highways leading north from the Texas-Mexico border. This sign assembly is presented in Figure II-2. The circles in the signs were red. The metric sign assembly was placed next to the typical day/night speed limit sign assembly.

Currently, there is limited use of bilingual and Mexican-style traffic signs in the Texas border areas. Figures II-3, II-4, and II-5 illustrate examples of these types of signs that were recently observed in the Rio Grande Valley.

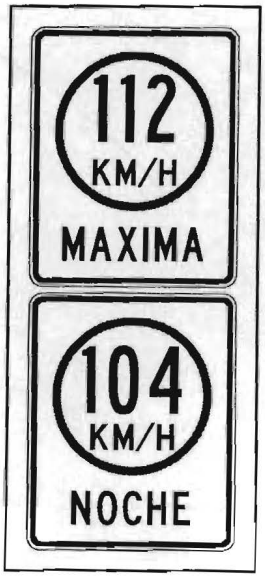

Figure II-2. 1971 THD Speed Limit Signs

Figure II-3. Bilingual Guide Sign in Texas

Figure II-4. Bilingual Regulatory Sign in Texas

Figure II-5. Mexican-Style Sign in Texas

Traffic Control Devices in Mexico

The Mexican system of traffic control devices shares many attributes with the U.S. (and Texas) system. For example, warning signs in both countries use a black-on-yellow, diamond-shaped format. Figure II-6 provides another comparison of key Mexican signs that are similar to their Texas counterparts. Even though the Mexican system of traffic control devices shares several attributes with the U.S. system, there are enough differences to potentially confuse a driver from Mexico coming into Texas. For example, Mexico does not use the circle, pentagon, pennant, or rectangular shapes for warning signs. Additionally, the Mexican driver is not accustomed to a large number of signs that use word message legends. Of course, the Mexican signs that do use word legends are in Spanish.

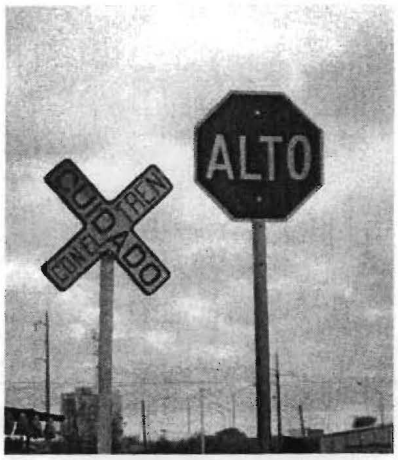

Figure II-6. Example of Similar Mexican Signs

Many of the symbols used in Mexican signs are different from those used in Texas. Furthermore, although the ALTO (STOP) and CEDA EL PASO (YIELD) signs use similar shapes, almost all of the other regulatory signs are completely symbol-based. In addition, most of Mexico uses an all-white system of pavement markings.

All units of measure in Mexico's signs are metric. A Mexican driver entering the Texas border area may have some difficulties understanding some of the Texas signs and pavement markings due to the differences between the systems. Figures II-7, II-8, and II-9 illustrate a few of the signs from the Mexican equivalent of the Texas MUTCD (9).

To a limited extent, TxDOT-sponsored research (10) conducted in 1993 addressed some of the concerns associated with signing and other traffic control devices on both sides of the Texas-Mexico border. This research found some limited bilingual signing on both sides of the border but indicated the need for more emphasis on this practice. Mexico was found to utilize the practice more than Texas. The research also indicated that fewer signs were used in work/construction areas in Mexico than in Texas. Surveys found that drivers on both sides of the border are concerned about foreign drivers' knowledge of local signing and traffic laws.

Traffic Control Devices in Other U.S. Border States

No prior research into meeting the needs of Spanish-speaking drivers' comprehension of U.S. traffic control devices has been located or obtained from the border states of California, Arizona, or New Mexico.

Florida, although not technically a border state with Mexico, shares many of the characteristics that make the border states unique. Florida has a large non-English speaking population, of which most are Spanish-speaking. Additionally, it has many foreign tourists who do not speak English. For these reasons, Florida was also considered for investigation into how to address these concerns.

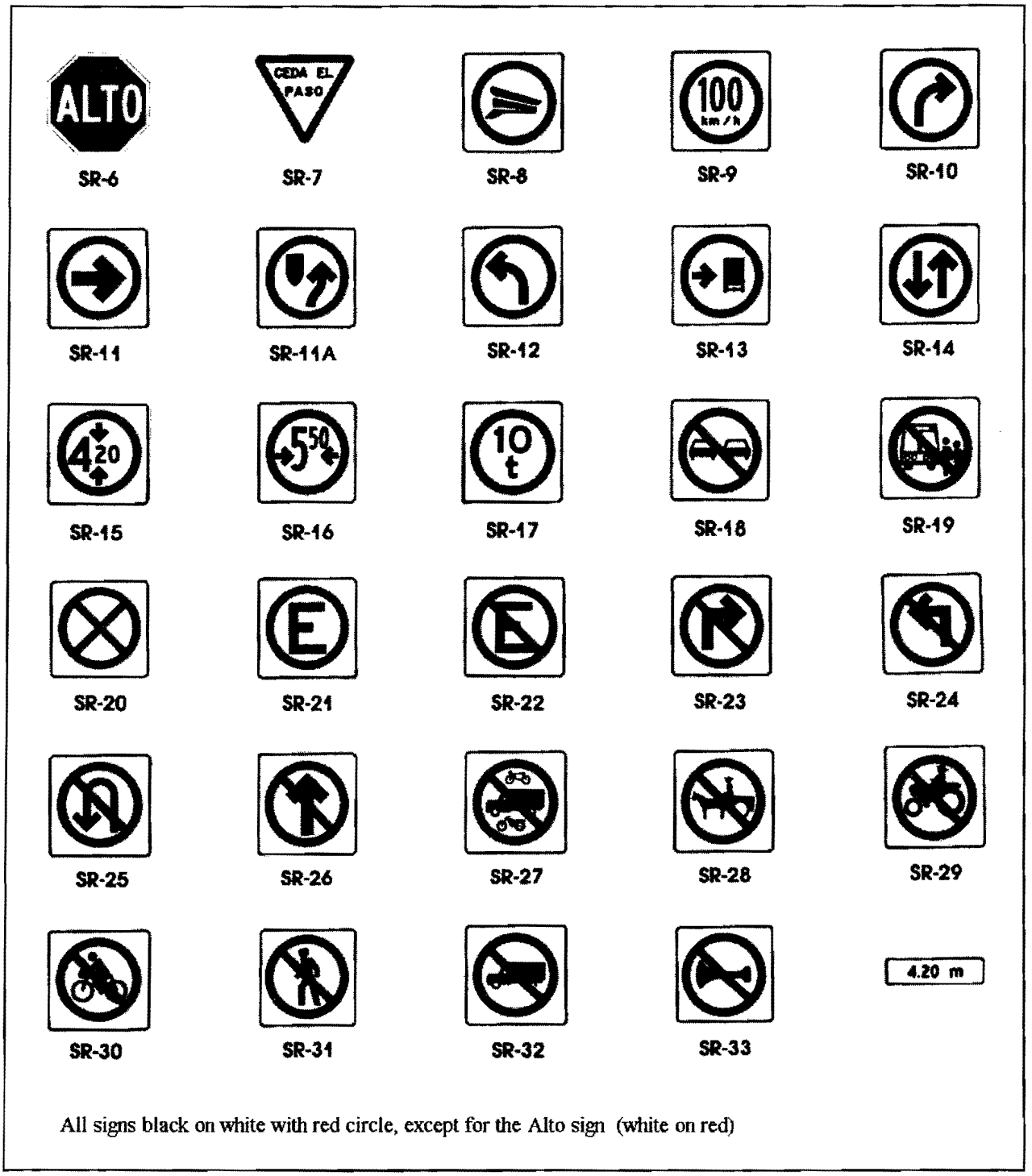

Figure II-7. Mexican Regulatory Signs

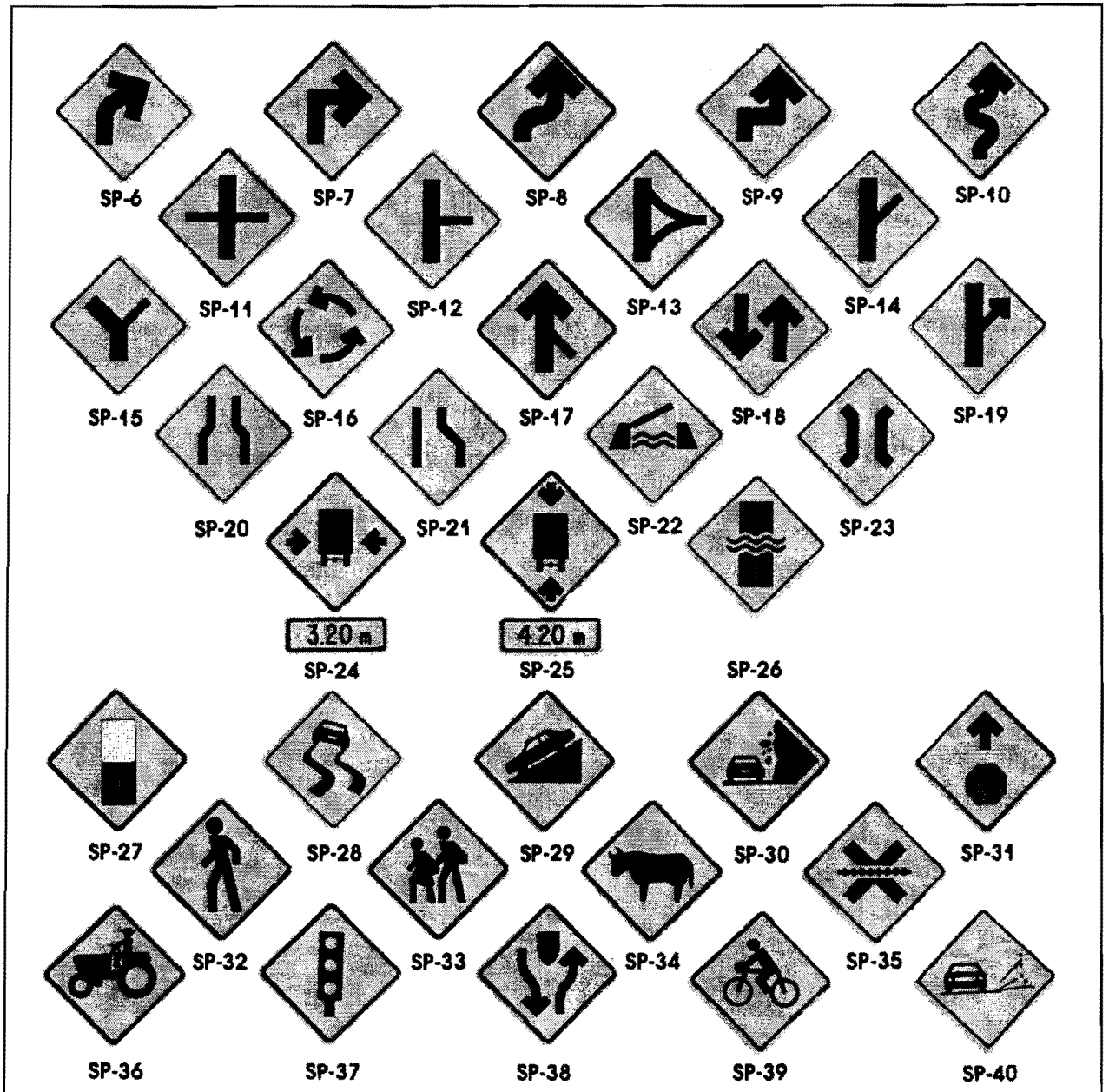

Figure II-8. Mexican Warning Signs

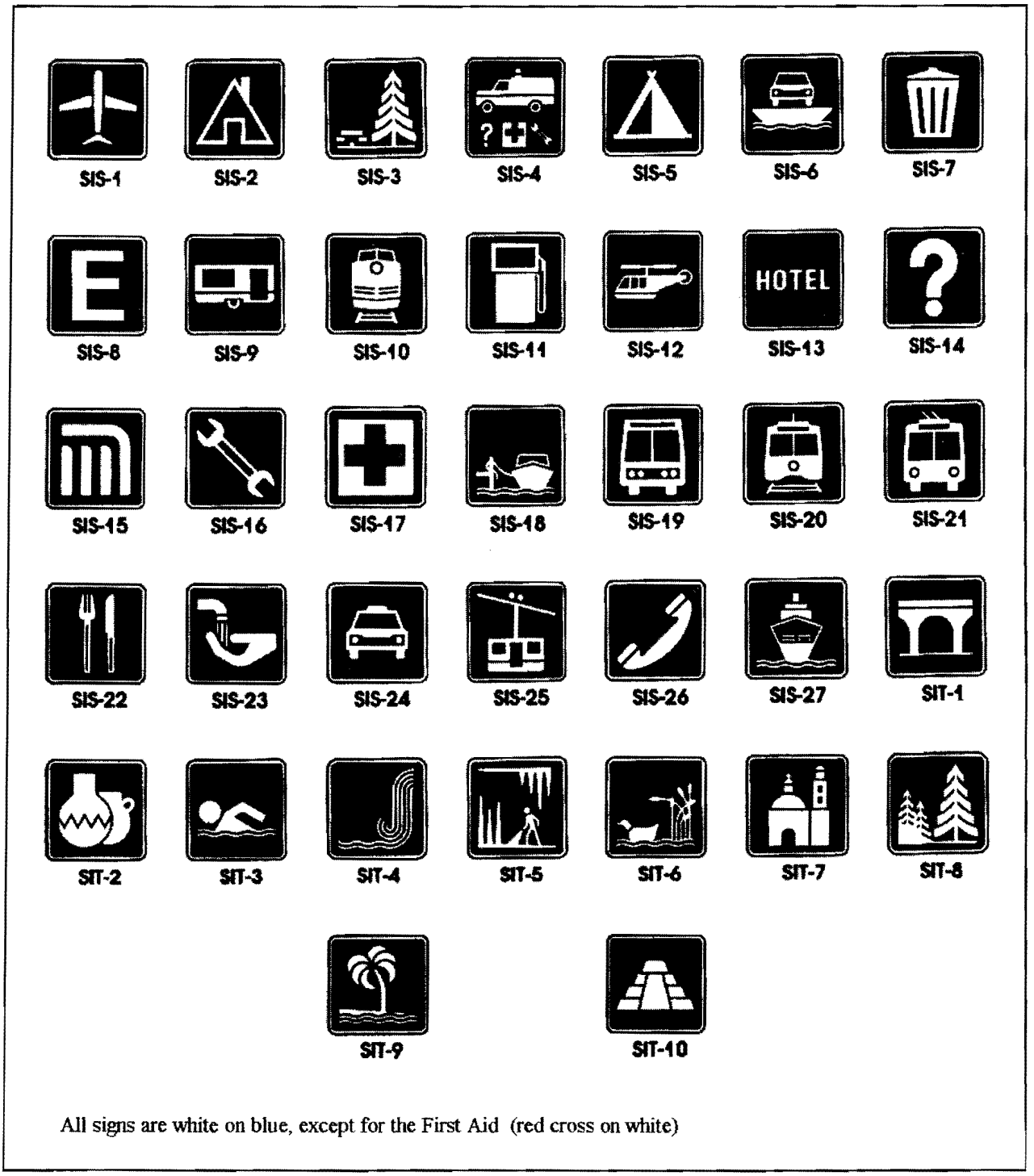

Figure II-9. Mexican Service Signs

New Mexico

Telephone interviews were conducted with personnel of the New Mexico State Highway and Transportation Department (NMSHTD). The results indicated that New Mexico uses the symbol versions of warning signs, when possible, to minimize the potential of non-English speaking drivers of misinterpreting or not understanding word-message signs. Also, within approximately 80

kilometers of the Mexico border, NMSHTD utilizes "dual" guide signing. A conventional destination sign (with U.S. customary units) is proceeded 150 meters by a similar destination sign with S.I. units. Personnel from New Mexico, however, emphasized that English and Spanish legends are not "mixed" on the same sign. Lastly, in an effort to improve communications between corresponding traffic agencies in Mexico, the NMSHTD has developed a reference guide that provides for better understanding and translation of technical transportation terms from Spanish to English and from English to Spanish (11).

California

Telephone interviews with the California Transportation Department (CalTrans) revealed that bilingual word-message signs are used (although sparingly) in the southern part of the state. One example of a word-message sign with a bilingual legend is the FASTEN SAFETY BELTS sign (R19-8). Other examples, used by the City of Los Angeles at grade crossings on the city's light rail system, contain dual language messages as well. One particular sign reads PHOTO CITATIONS ISSUED | INFRACCIONES REGISTRADAS FOTOGRAFICAMENTE; another reads RAILROAD CROSSING MONITORED BY CAMERA, PHOTO CITATIONS ISSUED | CRUCE OBSERVADO POR CAMARAS FOTO-CITACIONES EMITIDAS (12, 13). Although not discussed previously in this report, a difficulty associated with using dual language signing is evident in these two sign legends. A translation from English to Spanish typically results in a longer text legend, which may prove to be impractical to implement because of legibility concerns.

CalTrans also uses a limited number of symbol signs intended for bilingual drivers. Alternative sign symbols not necessarily used in the national MUTCD attempt to convey clearer meaning for both U.S. and Mexican drivers.

Arizona

Telephone interviews revealed that the Arizona Department of Transportation (ADOT) is increasing their use of bilingual signs near the Arizona-Mexico border (within 50 kilometers) and along major highway within the state. No specific directives or memorandums have been issued to the ADOT districts mandating the use and placement of the bilingual signs; districts, however, must receive administrative approval for each bilingual sign that is to be installed. The sign contains both English and Spanish text legends, with the English text typically above the Spanish text.

Florida

Although not located along an international border, the Florida Department of Transportation (FDOT) has many concerns over the ability of international tourists to understand their traffic signs. International tourism has played an increasingly important role in the health of Florida's economy. The incidences of international visitors being victims of random violence was believed to have a significant negative impact upon the number of tourists from foreign countries. FDOT determined that one challenge facing the international visitor is the interpretation of highway signing which can cause the visitor to become disoriented or lost while driving in Florida (14). Therefore, in 1994, FDOT contracted with Wilbur Smith Associates (WSA) and TTI to conduct a study entitled "Evaluation of International Signing Practices" (14, 15). In conducting this project, the WSA/TTI

team looked at international signing practices and methods of making Florida guide signing more understandable to international tourists. In the TTI effort of the project, TTI conducted surveys of over 500 international travelers to identify the driving problems of international visitors. Human factors/traffic engineering critical incident analyses were then performed of these driving problems. Positive guidance principles were then applied to develop practical recommendations to make Florida's roads safer and more "user friendly." The primary recommendations were tested by follow-up studies with other international drivers.

Traffic Control Devices in Other Countries

There are several countries that struggle with the issue of providing signing for a driving population that represents more than one language. Examples include Canada (English and French), India (Hindu and English), and Switzerland (German and French). The following paragraphs describe how traffic control devices are used in some of these countries and their efforts to promote international uniformity.

Canada

The Canadian MUTCD (16) contains examples of bilingual signs which are "intended to provide all jurisdictions with guidelines to assist in obtaining uniformity in bilingual signing, appropriate for use throughout Canada." Specific examples of each sign type are illustrated. The signs adhere to the following policies described in the Canadian MUTCD (Part E):

- The majority or dominant language of the province will be on top or on the left of the sign;
- Both languages should be on one sign, and areas for each language should be equal;
- Accents should be provided with the French legends;
- Names of municipalities, rivers, falls, bridges, streets, etc., should not be translated on highway signs; and
- Where bilingual signs are used, a policy of a strictly bilingual legend is recommended on regulatory, guide, and warning signs even though some words are easily identifiable in both languages.

Despite the guidelines listed above, Section A1.17 of the manual does seem to allow for messages in French and English being on separate signs. It reads, "*In the case of a French-language sign accompanying an English-language sign, both for the same purpose, the signs should be placed not more than 30m apart*" (16).

Europe

A document dealing with the topic of international drivers' comprehension of traffic control devices in Europe is "Trends in Road Signing in Europe" by M. Bernhard and published by the Transportation Research Board in 1985 (17). The abstract states, in part, that "*Europe is a mixture of cultures and political systems with many linguistic barriers,*" and "*it forms a strong economic body which depends on its road infrastructure,*" and "*therefore, the road network of Europe must have the equipment in road signing and markings allowing drivers from any country to feel safe and comfortable in any other country.*"

Bernhard states in the paper that the sign symbols are now similar in all countries of Europe, and that most sign legends have been abolished to deal with the language barriers. According to Bernhard, the only symbols still in text are the words STOP and BUS.

International

Attempts have been made, with some success, toward achieving more uniformity worldwide in traffic control devices. In 1909 the convention on the International Circulation of Motor Vehicles was held in Paris, France. This convention recommended four road signs depicting certain road hazards: humps, curves, road crossings, and railroad crossings. Many European countries ratified this convention recommendation. In 1926 the Convention Relative to Motor Traffic prescribed a modest system of six uniform signs, including the triangular-shaped "danger" sign in use today in Europe. In 1931 the Convention for the Unification of Road Signs was adopted at Geneva. The number of road signs specified increased to 26, and they were divided into three categories: danger signs, signs giving definite instructions, and information signs. In 1939 a committee of the League of Nations recommended further standardization of the international road sign system, but the Second World War postponed any implementation of the recommendations. The United Nations (U.N.) adopted a new protocol on road signs in 1949. It recommended more than 50 traffic signs and was agreed to by 30 nations. The U. N. recommended a world system of signing in 1953. This U.N. Draft Convention was not well-received, and ten years later, only two European countries had subscribed to it. The 1949 U.N. protocol is, therefore, the primary foundation of the current standardization (to the extent that standardization exists) (18).

Zuniga describes and evaluates sign recommendations made by the United Nations Conference on Road Traffic during the period 1967-68 (19). Devices used for equivalent situations were compared, and one, or in some cases, two style(s) were chosen as the preferred sign. It is apparent, by examining the many differences in sign types still in use in various countries, that the recommendations resulting from this conference have, in large part, not been implemented. The conference's recommendations as to the preferred sign types were expected to be used by countries that were just developing road networks and traffic signing. It was not expected that the highly developed countries on the various continents would completely change their signing procedures. However, the differences between signing in Mexico and the United States, even at that time, were not as great (as far as color and shape) as were the differences between the Americas and other continents. Most of the differences in Mexican and American signing is in the legends (Spanish vs. English) and in the picture symbol used on the sign.

The United Nations Economic Commission for Europe (UNECE) Conference on Road Traffic's 1968 Vienna Convention included recommendations for legends, or supplemental plates with legends, to go along with symbols when this might make the meaning more clear (20). These suggestions are taken from the Convention's recommendations:

- Nothing in this Convention shall prohibit the addition, in order to facilitate the interpretation of signs, of an inscription in a rectangular panel below the sign or in a rectangular panel containing the sign itself, if this does not make the sign more difficult to understand for drivers who cannot understand the inscription.

- Where the competent authorities consider it advisable to make the meaning of a sign or symbol more explicit or, in the case of regulatory signs, to limit their application to certain categories of road-user or certain periods, and where it would not be possible to convey the necessary information by an additional symbol or by numerals as provided in the annexes to this Convention, an inscription shall be placed below the sign in a rectangular panel.
- The inscriptions referred to in paragraphs 3 and 4 of this Article shall be in the national language, or in one *or more* of the national languages, and also, if the Contracting Party concerned considers it advisable, in other languages, in particular official languages of the United Nations.

The Geneva European Agreement of May 1, 1971 further refined sign standardization (17).

NAFTA WORKING GROUP ON TRAFFIC CONTROL DEVICES

As previously mentioned, NAFTA is expected to have a significant impact on the transportation system in all three partner countries (Canada, United States, and Mexico). These countries have created several committees in an effort to address some of the most significant of the issues created by NAFTA. One of these is the Land Transportation Standards Subcommittee, which has five working groups. Working Group 3—Traffic Control Devices for Highways, is responsible for seeking compatibility of practices related to traffic control devices. To date, the group has compared the three national manuals for traffic control devices, identified differences, and developed initial recommendations. The working group found that the majority of signs used in the three countries are similar in shape, color, and design and that commercial and private drivers will experience only minimal inconvenience due to the differences. The group did identify several traffic control device issues where differences occur among the countries. These differences are described below.

- **Metric Units** - Both Mexico and Canada use the S.I. system, while the United States uses the U.S. Customary system of measurements. For speed and distance measurements, the differences are primarily an inconvenience to drivers. However, for height, width, and weight restrictions, the differences are critical for truck traffic.
- **Speed Limit Sign** - Each country uses a different design for its speed limit signs. Mexico's is similar to the European system (number in a red circle) while the other countries use a black on white number with words ("Speed Limit" in the U.S. and "Maximum" in Canada). In both the U.S. and Canada, a red circle is used only on prohibition signs.
- **Permissive Signs** - Each country uses a different method of indicating permissive and mandatory movements at an intersection. These could cause difficulties for those drivers who are not familiar with each country's methods.
- **Word Message Signs** - The U.S. has a higher proportion of word message signs, although all three countries use some word message signs. These signs could pose difficulties for those drivers who do not speak the language used in the sign.
- **Color of Pavement Markings** - The U.S. and Canada use a yellow/white pavement marking system while Mexico uses an all-white system (although some Mexican states that border the U.S. use a yellow/white system).
- **Dangerous Goods/Cargo Signs** - Each country has a different method of signing for hazardous cargo. Canada uses a symbol, the U.S. uses the letters "HC," and Mexico uses

a word message sign. This issue was forwarded to Working Group 5—Handling Hazardous Cargo.

- **Symbol Signs** - Although there are some differences in symbols among the countries, most symbols should be understandable. The weight limit symbol ("t" for metric ton versus "T" for English ton) could cause some confusion.
- **Construction Traffic Control Devices** - The specific signs used in work zones in the three countries are different.

The working group has developed a three-part action plan to address differences between traffic control devices. The action plan includes the following elements:

- **Brochure**- The working group is in the process of developing a pamphlet for distribution at border crossings. This brochure will describe the differences in rules of the road and traffic control devices among the three countries. Initial drafts of the brochure have been targeted to commercial drivers, and the brochure appears as if it will be several pages in length.
- **Dual message signing** - The working group recommends that limited dual message signs be placed near the borders and crossings on selected heavily traveled NAFTA corridors. These signs are expected to focus primarily on speed limit and word-message signs directed mainly toward commercial vehicle drivers.
- **Information Exchange** - The working group recommends that a method of exchanging future information on changes to traffic control devices be established between the three countries.

SUMMARY OF RESEARCH ON LINGUISTICS IN SIGNING

There has been limited research in other countries related to linguistic aspects of traffic signs, particularly with respect to bilingual signs. A few of the key findings from these studies are described in the following paragraphs.

Canada

"Design and Comprehension of Bilingual Traffic Signs," by P.B. Lessage for the benefit of Transport Canada published in 1981, is a research report dealing with Canadian practices (21). The report contains the following findings:

- Bilingual signs require more reading time than monolingual signs;
- The dominant language should be located either at the "top" of a "top-bottom" sign legend configuration, or at the "left" of a "left-right" configuration;
- Neither the "top-bottom" nor the "left-right" sign legend configuration was found to be significantly better than the other;
- Clear demarcation of the two languages (for example, by a line) significantly improved sign performance, particularly for monolingual driving subjects; and
- Use of "pivot" words (a word common to both languages) resulted in poorer sign performance than corresponding fully-translated signs.

England (Wales)

Probably the most in-depth study of bilingual signs is a 1972 research study conducted in England (22). This project researched the use of bilingual signs (Welsh and English) in Wales. Many types of signs, including directional, warning, and regulatory signs, were investigated using various bilingual legend configurations on each. The findings and recommendations resulting from their research include:

- Adding Welsh to direction signs increases the reading times of most signs;
- There is a greater increase in reading times on directional signs if a Welsh legend is positioned above an English legend;
- When destination names (in two languages) were paired by brackets, the reading time for a bilingual three-destination sign was shorter than the reading time for a monolingual six-destination sign;
- The results for the warning and regulatory signs which had supplementary plates bearing word messages were similar to those for the direction signs, namely that adding a plate bearing the message in Welsh increased the reading time, and the increase was greatest if the Welsh plate was positioned above the English one; and
- If further signs in Wales are to be made bilingual, the Welsh should be added below the English.

It should be noted that most of subject pool participating in the England study were English drivers. Furthermore, the few Welsh-speaking subjects that participated in the study all stated that they were accustomed to reading English legends on road signs. No monolingual Welsh drivers were a part of these tests.

Further research was conducted by this same laboratory in 1974 (23). This time, Welsh drivers who only speak Welsh were included. Not surprisingly, these drivers had quicker comprehension of the signs when the Welsh version of the legend was placed above the English version. However, as the author noted in the conclusion, there are many more English-speaking drivers than Welsh-speaking drivers, and the safer legend combination would still be English on the "top" and Welsh on the "bottom."

RELATED RESEARCH ON COMPREHENSION OF TRAFFIC CONTROL DEVICES

As recently as 1990, TxDOT sponsored an evaluation of motorist understanding of traffic control devices (24). During the first three years of that project, the Texas Transportation Institute conducted five different evaluations in order to assess driver comprehension of traffic control devices. The first and most comprehensive of these evaluations was a statewide survey which addressed 46 devices and was given to 1,745 Texas drivers. The survey was conducted in 12 driver licensing stations located in six geographic regions of Texas in 1991. Two of the locations were along the Texas-Mexico border. The survey sample was selected such that it was representative of the driving population of Texas with respect to gender, age, and ethnicity.

As part of the current research project, the researchers reanalyzed the earlier comprehension data to evaluate comprehension differences in the border areas. Tables II-2, II-3, and II-4 compare the

correct response rates for the survey results for three sample categories: overall sample of 1,745 Texas drivers, border city sample of 156 drivers in El Paso and Eagle Pass, and non-border city sample of 1,589 drivers in 10 cities not located on the Texas-Mexico border. The border and non-border data was not presented in this format in the original research report.

Table II-2. Marking and Signal Comprehension in the 1991 TTI Survey

Device	Percent Correct			Statistically Different	Border > 10% lower
	Overall	Border	Non-Border		
Single Broken Yellow Centerline marking	76.8%	66.0%	77.9%	Yes	Yes
No-Passing Zone markings	88.0%	87.2%	88.0%	No	No
Solid White Edge Line marking	74.7%	63.5%	75.8%	Yes	Yes
Single Broken White Lane Line marking	50.3%	38.5%	51.5%	Yes	Yes
Double Solid White Lane Line marking	61.0%	60.9%	61.0%	No	No
Two-Way Left Turn markings	58.6%	48.1%	59.6%	Yes	Yes
Preferential Lane (diamond) marking	65.3%	54.5%	66.3%	Yes	Yes
Yellow Arrow signal	80.4%	78.8%	80.6%	No	No
Flashing Yellow Ball signal	80.7%	71.2%	81.7%	Yes	Yes
Flashing Red Beacon signal	41.1%	33.3%	41.9%	Yes	No
Flashing Yellow Beacon signal	54.0%	44.9%	54.9%	Yes	Yes
Steady Red X Lane-Use Control signal	74.9%	58.3%	76.5%	Yes	Yes

Table II-3. Regulatory Sign Comprehension in the 1991 TTI Survey

Device	Sign Code	Word or Symbol	Percent Correct			Statistically Different	Border > 10% lower
			Overall	Border	Non-Border		
Yield	R1-2	Word	79.4%	73.7%	80.0%	Yes	No
Reduced Speed Ahead	R2-5a	Word	93.2%	85.3%	94.0%	Yes	No
Speed Zone Ahead	R2-5c	Word	55.0%	51.9%	55.3%	No	No
Mandatory Turn	R3-7	Word	79.5%	70.5%	80.4%	Yes	No
Double Turn	R3-8L	Symbol	65.0%	50.0%	66.5%	Yes	Yes
Two-Way Left Turn Lane	R3-9b	Symbol	44.6%	35.9%	45.4%	Yes	No
HOV Restriction	R3-14	Word	45.7%	32.1%	47.0%	Yes	Yes
Slower Traffic Keep Right	R4-3	Word	70.8%	57.1%	72.1%	Yes	Yes
Do Not Cross Double White Line	R4-3B	Word	72.6%	71.2%	72.8%	No	No
Keep Right	R4-7	Symbol	69.9%	59.0%	71.0%	Yes	Yes
Protected Left on Green Arrow	R10-9	Word	53.0%	44.9%	53.8%	Yes	No
Protected Left on Green	R10-9a	Word	15.5%	9.0%	16.1%	Yes	No
Left Turn Yield on Green Ball	R10-12	Word	74.5%	65.4%	75.4%	Yes	Yes

Table II-4. Warning and Other Sign Comprehension in the 1991 TTI Survey

Device	Sign Code	Word or Symbol	Percent Correct			Statistically Different	Border > 10% lower
			Overall	Border	Non-Border		
Turn	W1-1	Symbol	31.9%	28.2%	32.2%	No	No
Curve	W1-2	Symbol	32.4%	26.3%	33.0%	Yes	No
Reverse Turn	W1-3	Symbol	66.5%	50.6%	68.0%	Yes	Yes
Stop Ahead	W3-1a	Symbol	87.4%	85.3%	87.6%	No	No
Lane Reduction Transition	W4-2	Symbol	61.2%	53.8%	61.9%	Yes	No
Narrow Bridge	W5-2a	Symbol	81.7%	78.8%	82.0%	No	No
Divided Highway Ends	W6-2	Symbol	50.7%	47.4%	51.0%	No	No
Slow Down on Wet Road	W8-5	Symbol	62.3%	55.1%	63.1%	Yes	No
Rough Road	W8-8	Word	88.7%	83.3%	89.2%	Yes	No
Grooved Pavement Ahead	W8-12	Word	29.2%	30.1%	29.1%	No	No
Lane Ends Merge Left	W9-2	Word	64.0%	48.7%	65.5%	Yes	Yes
RR Advance Warning	W10-1	Symbol	77.8%	71.8%	78.4%	Yes	No
Parallel RR Advance Warning	W10-3	Symbol	69.3%	58.3%	70.4%	Yes	Yes
Truck Crossing	W11-10	Symbol	66.1%	52.6%	67.5%	Yes	Yes
Limited Sight Distance	W14-4	Word	44.9%	34.6%	45.9%	Yes	Yes
Watch for Ice on Bridge	W19-2	Word	84.0%	76.9%	84.7%	Yes	No
Ramp Metered When Flashing	W19-3	Word	45.7%	43.6%	45.9%	No	No
Warning Sign Shape & Color	---	---	58.1%	50.6%	58.8%	Yes	No
School Speed Limit	S5-1	Word	79.0%	67.9%	80.1%	Yes	Yes
Type 3 Object Marker	OM-3	Word	61.9%	59.0%	62.2%	No	No
Guide Sign Color	--	---	75.1%	66.7%	76.0%	Yes	No

The analysis of this data indicates that there are numerous traffic control devices in which the comprehension in the border areas is less than that in the rest of the state. For several of the devices, the comprehension levels in the border areas are more than 10 percentage points less than levels in the rest of the state. There are several factors, however, that were considered in interpreting this data. The survey was administered only to Texas residents and only an English-language survey was administered. Lastly, many of the questions addressed some subtle aspects of the meaning of a particular traffic control device. For instance, the question for the "flashing red beacon signal" did not ask for an interpretation of a red beacon; rather, it asked the driver to identify the color of the beacon that drivers on the intersecting roadway would see. As a result of these factors and others, the data was interpreted within the context of the questions and the possible response choices.

SUMMARY OF TELEPHONE INTERVIEWS

In order to identify opinions and perceptions at the local levels, the researchers conducted telephone interviews of personnel from transportation agencies, tourist organizations, and

commercial transportation businesses on both sides of the border. Interviews of U.S. officials were conducted in English and those of Mexican officials were generally conducted in Spanish.

Interviews of U.S. Officials

Telephone interviews were conducted of various agencies along the border, including several TxDOT districts, other border states, border cities, tourist bureaus, chambers of commerce, and trucking companies. Typically, the communication consisted of an interview with a traffic engineer, a maintenance supervisor, or a sign supervisor. In some cases, the communication was with a person in an "international liaison" position.

TxDOT Districts

- The TxDOT districts frequently mentioned the use of metric/Spanish speed limit signs on major highways traveling north from border cities. In some cases, they are also used on highways paralleling the border, such as FM 170 in Presidio County, on U.S. 277 in Maverick County, and on interstates in the El Paso vicinity. There are two methods of using metric speed limit signs: dual posting (side-by-side with the standard U.S. speed limit sign) or on totally separate assemblies several hundred feet apart. Some of these signs have been in place for as long as ten years.
- Some TxDOT personnel also mentioned a few cases where bilingual or dual language signs are in use. Examples include:
  - Spanish language tourist bureau signs in Laredo,
  - Bilingual weight limit signs in El Paso,
  - Dual posting Stop for School Bus signs in the Eagle Pass area, and
  - Spanish Border Patrol signs in the Laredo area.
- The Del Rio district tries to use symbol alternatives to word message legends whenever possible (i.e., when an alternative exists, such as for lane ends/road narrows, truck crossing, deer crossing, etc.).
- The Laredo District is attempting to develop, with the help of the Texas Department of Public Safety (DPS), a manual to be given to motorists as they enter the United States. This manual would explain traffic control devices and their use. The Laredo District meets occasionally with the Mexican state DOTs of Nuevo Leon, Tamaulipas, and Coahuila to discuss work zone issues.

Other State DOT's

- New Mexico attempts to use symbol alternatives whenever possible. Within 80 kilometers (50 miles) of the border, they frequently have dual destination and guide signs. The first sign uses English units (miles), the second sign in metric units (kilometers) is located about 150 meters (500 feet) downstream.
- Arizona is increasing its use of bilingual signs, especially within 50 kilometers (30 miles) of the border and on major highways. Both languages are on the same sign, with the English legend being on top.

- California does not have any signs with metric units yet. However, they have a few bilingual signs for such information as "Fasten Seat Belts," "Pedestrian Crossing," and "Last Exit."
- None of the agencies contacted thus far knew of any special initiatives or any research being conducted with regards to traffic control devices and driver information needs in the border area.

Interviews of Mexican Officials

Interviews were also conducted, in Spanish, of various Mexican officials and representatives of trucking companies. The results of these surveys are described below.

- Mexican transportation officials stated that the major problem in interpreting U.S. traffic signs, in general, is the implementation of English units in sign legends. An example of this is on the Speed Limit sign, which uses miles per hour as the unit of measurement. The use of English units makes it confusing since most speedometers on Mexican vehicles are in kilometers per hour.
- Some officials indicated a belief that U.S. traffic regulations are not fully understood by Mexican drivers. Those drivers who may have a basic understanding of the regulations experience frustrations when the regulations are not practiced uniformly from state to state.
- Several individuals noted that Mexican tourists had difficulty locating car repair shops when on the freeway system.
- Tourist bureau officials indicated that the use of route numbers to identify highways made navigation more difficult. They indicated that drivers preferred the use of destination signing. The same officials also mentioned the difficulties created by the use of the English system of measurement, as opposed to the metric system.
- In Mexico, a program called PAISANO provides information regarding Mexican traffic regulations, immigration requirements, the Federal Highway Police, and other information to Mexican-American tourists coming into Mexico. This information is available from a portable stand located in the Mexican customs inspection facility. The same officials indicated an interest in participating if a similar program could be developed for Mexican tourists entering the United States.
- The Mexican trucking companies surveyed indicated that drivers are not required to speak English in order to drive across the border into the U.S. An exception to this rule is drivers transporting hazardous materials.
- Some companies indicated that communication by CB radio is very helpful for drivers that get lost while driving in the United States.

CHAPTER III
SURVEY ACTIVITIES

The first year of this research project was devoted to information gathering and problem identification. The previous chapter described the information acquired from the literature and various organizations or individuals. However, the most intensive first-year efforts were devoted to developing and administering two different surveys: a critical incident survey and a survey of driver comprehension of existing traffic control devices. Both of these surveys focused on drivers coming into Texas from Mexico.

As originally proposed, the critical incident survey was scheduled for the first year of the project and the driver comprehension survey was scheduled for the second year of the project. However, the first phase of the critical incident survey, which addressed short-haul truck drivers, did not produce sufficient information for indicating navigational difficulties. Therefore, the researchers accelerated the project schedule so that the driver comprehension survey (originally a second-year activity) could be developed and administered during the first year.

CRITICAL INCIDENT SURVEY

At the beginning of the research project, the researchers were concerned that navigation was a significant difficulty of Mexican drivers entering Texas. Therefore, a critical incident survey was developed to assess the effectiveness of guidance information.

The critical incident survey is a human factors technique used by TTI in previous studies of guide signs (15, 25) to identify highway locations where drivers become lost or confused. The survey is conducted by interviewing drivers to identify locations where they were lost or confused. The interviewers ask specific questions about these locations and attempt to confirm the exact location of the difficulty, attempting to discern the reasons the driver may have been lost or confused. These locations are described as the "critical incident sites." Information is then gathered about these sites. The information may include photos, videotapes, or design plans. A human factors/traffic engineering analysis is then conducted using this information to identify common characteristics and specific signing deficiencies that might cause navigational difficulties. The survey is not intended to identify all locations where drivers are experiencing navigational difficulties. Rather, it is intended as a screening tool that can be used to identify and classify typical navigational difficulties of the target population.

The critical incident survey developed for this project was based on the critical incident survey developed by TTI for evaluating international drivers in Florida (15). Researchers from the University of Texas - Pan American (UTPA) attempted to administer the survey to short-haul truck drivers at several border locations. Unfortunately, the UTPA researchers were not able to identify any drivers who were able to describe specific sites where they had navigational difficulties. As a result, the critical incident survey did not provide any information that could be used in the first-year problem identification effort. There may be several reasons why the desired information was not obtained. Some of the more likely reasons are listed below.

- Respondents could not remember sufficient details associated with an incident of being lost or confused;
- Respondents could not identify the specific location where they were lost or confused;
- Respondents traveled only in familiar areas; and
- Respondents would not admit to having been lost or confused.

TRAFFIC CONTROL DEVICE SURVEY

Once it appeared that the results of the critical incident survey would provide limited information, the researchers began development of a survey to evaluate driver comprehension of traffic control devices. The comprehension survey was developed in three phases. The first phase was a pretest administered in College Station, the second phase was the pilot survey administered in McAllen, and the third phase was the final survey administered in El Paso and McAllen.

Pretest Survey

The initial development of the comprehension survey began with a pretest instrument. In developing the pretest instrument, the researchers developed a format and procedure for the survey, selected the devices to include in the survey, and identified the responses that were most likely to be given for each device. Once prepared, the survey was administered to the Texas A&M University chapter of the Committee for the Awareness of Mexican American Culture and to an "English as a Second Language" class at Texas A&M. The information gained from the pretest survey was used to develop the pilot survey. The actual comprehension results of pretest survey were not analyzed for several reasons. First, the survey was not administered at a border location. This meant that the survey sample was not necessarily representative of the border area. Furthermore, the survey questions were in the early developmental phase and did not always provide the information needed to assess driver understanding of traffic control devices.

Pilot Survey

The pilot survey was conducted, as is appropriate, to test the survey instrument, the survey technique, and the method of analysis. The pilot survey was a crucial element of the research process, as the researchers had little experience with administering this type of survey under the particular circumstances of this project. The intent of the survey was to identify aspects of the survey content and administration procedure needing improvement.

The pilot survey addressed 26 devices and was administered to approximately 300 drivers at the international port crossing between Reynosa, Tamaulipas and McAllen, Texas in May 1996.. The survey was given to drivers while waiting in the queue to cross the bridge from Mexico to Texas. The survey utilized a flashcard format where the surveyor presented a flashcard with an image of a traffic control device, then asked a question about the sign. The driver's response was recorded on a data form by the surveyor. To expedite the data recording process, typical answers were provided on the data form. If the response was different from one of the expected responses, the surveyor wrote that response on the form. The surveyor showed the driver as many flashcards as possible while the vehicle was in the bridge queue. Therefore, the number of questions per driver varied from just a few to many. The survey was administered over a two-day period (Friday and Saturday) and included both commercial/business and tourists drivers coming into Texas from Mexico.

For the analysis, the survey responses which were not one of the expected answers on the data form were first translated from Spanish to English. Each response was then categorized into one of four results: *correct*, *partially correct*, *incorrect*, or *not sure*. The definitions of these categories for each device are given in Appendix A. Percentages were calculated for each response to every device. Table III-1 summarizes comprehension results for the devices in the pilot survey. Appendix A provides a more detailed analysis of the results and a table summarizing the demographic characteristics of the pilot survey sample.

Table III-1. Results of the Pilot Survey

Device	No. of Drivers	Response Rates (percent)			
		Correct	Partially Correct	Incorrect	Not Sure
Stop sign	69	99	N/A	1	0
Yield sign	81	40	N/A	41	20
Do Not Enter sign	82	72	N/A	23	5
Day/Night Speed Limit signs	69	39	41	16	4
Day/Night Truck Speed Limit signs	79	11	38	51	0
Mexican Speed Limit sign	86	26	42	33	0
One Way sign	82	2	44	48	6
Protected Left on Green Arrow sign	79	5	15	77	3
Left Turn Yield on Green Ball sign	65	2	14	82	3
Two Way Left Turn sign	67	5	10	84	2
Crossbuck sign (meaning)	69	0	68	26	6
Crossbuck sign (location)	60	50	N/A	48	2
Stop for School Bus Loading or Unloading sign	60	0	26	74	0
Fasten Safety Belts - State Law sign	85	11	22	14	53
Trucks Use Right Lane sign	74	50	16	18	16
Weight Limit 10 Tons sign	77	21	34	31	14
Hazardous Cargo Route sign	80	1	N/A	15	84
Hazardous Cargo Prohibited sign	68	0	3	22	75
Single Broken Yellow Center Line marking	84	0	33	57	10
No Passing Zone marking	72	0	32	61	7
Double Solid White Line marking	78	19	N/A	73	8
Hill sign	72	0	36	46	18
Clearance sign	86	24	27	27	22
Right Lane Ends sign	80	10	N/A	71	19
Advisory Speed Plate	67	27	22	49	2
School Bus Stop Ahead sign	79	1	6	87	4
Right Lane Closed 500 Ft	78	0	32	54	14

Note: N/A - there is no acceptable partially correct response to the question for this device.

It should be noted that to be classified as *correct*, many responses required mention of some subtle aspects of the sign definition. For example, to be classified as *correct*, responses to the Crossbuck sign (R15-1) required the driver to state that the device indicated a railroad crossing *and* that the sign is located at the crossing location (as opposed to an advance sign placement).

Final Survey

Once the pilot survey was administered and the results had been analyzed, the researchers identified several areas where the survey could be improved. Therefore, changes were made to the devices addressed in the survey, the format of the questions, and the procedure for administering the survey. This final survey addressed 33 devices and was administered to over 750 drivers at international port crossings in El Paso, McAllen, and Pharr, Texas.

A significant change in the final survey was the inclusion of formal follow-up questions to the primary survey questions. These follow-up question(s) were necessary to ascertain whether a driver understood some of the subtle meanings of devices and to allow comparisons between driver responses. In the pilot survey, the form and content of follow-up questions was at the discretion of the person administering the survey. However, this made it difficult to compare the responses of different survey participants.

The results of the pilot survey also indicated the need to make other changes in the final survey instrument. These changes included the addition of some devices, deletion of other devices, and improved graphics, as well as changes in survey administration. The method of recording responses on the data form did not provide the necessary level of detail needed for a thorough analysis. In the final survey, drivers' responses were recorded on a tape recorder. The tape-recorded responses were then categorized as *correct*, *partially correct*, *incorrect*, and *not sure*. A fifth category, *indeterminate*, was added to account for responses that were either inaudible on the tape during playback or where a mechanical failure occurred during the survey administration.

The final survey was administered at the same international port crossings in McAllen and Pharr, Texas, as well as in El Paso, Texas, in August 1996. As with the pilot survey, this survey was given to drivers while waiting in the queue to cross the bridge from Mexico to Texas. The survey utilized a similar flashcard format, where the surveyor would present to a driver a flashcard with an image of a traffic control device, and ask a question about the device. The driver's response was recorded on audio tape for later analysis. The surveyor showed the driver as many flashcards as possible while the vehicle was in the bridge queue. Therefore, the number of questions per driver varied from just a few to many. The survey was administered over a three-day period in each city. The days were Thursday, Friday, and Saturday and included both commercial/business and tourist drivers coming into Texas from Mexico.

The devices presented were divided into four sets. Set 1 contained basic traffic control devices that address right-of-way and speeds, Sets 2 and 3 contained a variety of devices, and Set 4 contained the devices related to trucks. Each set contained approximately 8 devices. The survey sets, or portions thereof, were administered to a total of 759 drivers. Each driver answered an average of about 23 questions. For Sets 1 through 3, there were at least 500 responses to the primary question for each device, with many devices having over 600 responses.

For each device, a researcher listened to the recorded response to the primary question, interpreted the response according to the criteria, and recorded the answer category (*correct*, *partially correct*, *incorrect*, *not sure*, or *indeterminate*.) on a data form. Appendix B contains the criteria used to classify the responses to each question. Responses to follow-up questions, if any, were interpreted in the same manner. Typically, if a response did not meet the criteria for a *correct* or *partially correct* answer, the response was categorized as *incorrect*.

The analysis of the survey responses was a time-intensive effort, as a total of some 17,500 responses were interpreted. Tables III-2, III-3, III-4, III-5, III-6, and III-7 summarize the comprehension results for the different types of devices addressed in the final survey. Appendix B provides a more detailed analysis of the results and a summary of the demographic characteristics of the final survey sample.

Table III-2. Final Survey Results for Regulatory Signs

Device	Question	Sample Size	Response Rates (percent)				
			Correct	Partially Correct	Incorrect	Not Sure	Unknown
Stop sign	Primary	601	98.7	0.0	0.5	0.2	0.7
Yield sign	Primary	603	63.9	0.0	21.5	13.6	1.0
Day/Night Speed Limit signs	Primary	601	82.3	15.2	1.3	0.5	0.7
	Follow-up	462	82.5	0.0	9.7	6.1	1.7
Do Not Enter sign	Primary	582	90.7	0.0	4.6	3.4	1.2
One Way sign	Primary	560	83.3	0.0	13.8	1.6	1.3
Stop for School Bus Loading or Unloading sign	Primary	557	57.9	24.2	14.6	3.3	0.0
	Follow-up	274	64.6	0.0	27.4	5.4	2.5
Fasten Safety Belts - State Law	Primary	587	33.2	23.2	5.5	36.6	1.5
	Follow-up	156	89.2	0.0	7.0	1.3	2.6

Table III-3. Final Survey Results for Warning Signs

Device	Question	Sample Size	Response Rates (percent)				
			Correct	Partially Correct	Incorrect	Not Sure	Unknown
Curve sign with Advisory Speed Plate	Primary	528	65.4	30.8	2.5	1.0	0.4
	Follow-up	62	76.9	0.0	20.0	1.6	1.6
	Follow-up	114	44.1	48.7	4.5	1.8	0.9
	Follow-up	42	86.4	2.3	9.1	0.0	2.3
Two-Way Traffic sign	Primary	538	93.3	0.6	4.1	1.9	0.2
Advance Railroad Warning sign	Primary	602	39.1	40.5	6.5	12.8	1.2
School Crossing sign	Primary	545	52.3	34.3	11.6	1.5	0.4
	Follow-up	125	68.5	0.0	29.1	1.6	0.8
	Follow-up	63	63.9	0.0	32.8	3.3	0.0

Table III-4. Final Survey Results for Other Signs

Device	Question	Sample Size	Response Rates (percent)				
			Correct	Partially Correct	Incorrect	Not Sure	Unknown
Road Work Ahead sign	Primary	579	80.3	1.0	2.9	14.9	0.9
	Follow-up	380	64.5	28.7	5.8	0.0	1.1
	Follow-up	4	88.9	0.0	0.0	0.0	11.1
Two Right Lane Ends signs - One Orange and One Yellow	Primary	502	8.4	11.2	16.9	62.3	1.2
	Follow-up	328	46.5	6.0	19.3	32.6	1.5

Table III-5. Final Survey Results for Truck Related Signs

Device	Question	Sample Size	Response Rates (percent)				
			Correct	Partially Correct	Incorrect	Not Sure	Unknown
Day/Night Truck Speed Limit signs	Primary	144	63.9	29.9	4.2	1.4	0.7
	Follow-up	111	92.0	0.0	7.2	0.9	0.0
	Follow-up	116	65.5	0.0	31.0	2.6	0.9
Low Clearance sign	Primary	134	67.7	11.3	9.0	9.8	2.3
Weight Limit 10 Tons sign	Primary	132	68.8	17.2	8.6	5.5	0.0
Load Zoned Bridge sign	Primary	126	1.6	5.7	40.3	50.8	1.6
	Follow-up	12	16.7	0.0	58.3	16.7	8.3
Weigh Station Next Right sign	Primary	124	29.8	3.2	25.8	39.5	1.6
	Follow-up	28	79.3	0.0	10.3	6.9	3.5
	Follow-up	29	83.3	3.3	3.3	6.7	3.3
Hill sign	Primary	121	64.2	22.5	10.8	2.5	0.0
	Follow-up	74	67.7	0.0	30.7	1.3	1.3
Hazardous Cargo Route sign	Primary	118	31.4	0.9	14.4	53.4	0.0
	Follow-up	20	65.0	0.0	5.0	20.0	10.0
Hazardous Cargo Prohibited sign	Primary	116	28.1	11.4	21.1	39.5	0.0

Table III-6. Final Survey Results for Pavement Markings

Device	Question	Sample Size	Response Rates (percent)				
			Correct	Partially Correct	Incorrect	Not Sure	Unknown
Broken Yellow Centerline Pavement Marking - 1-way or 2-way	Primary	593	72.2	0.0	25.3	1.5	1.0
Broken Yellow Centerline Pavement Marking - passing restrictions	Primary	589	36.8	38.0	22.8	0.5	1.9
No Passing Zone Pavement Markings	Primary	573	84.1	0.0	12.2	1.9	1.8
Broken White Lane Line Pavement Marking - 1-way or 2-way	Primary	503	51.5	0.0	45.2	2.6	0.8
Broken White Lane Line Pavement Marking - passing restrictions	Primary	494	81.8	0.0	14.3	1.4	2.4

Table III-7. Final Survey Results for Traffic Signal Indications and Signal Signing

Device	Question	Sample Size	Response Rates (percent)				
			Correct	Partially Correct	Incorrect	Not Sure	Unknown
Red Ball signal indication	Primary	600	97.7	0.0	2.0	0.0	1.0
Yellow Ball signal indication	Primary	600	97.7	0.5	2.0	0.2	0.2
Green Ball signal indication	Primary	596	97.6	0.3	0.7	0.2	1.2
Green Left Arrow signal indication	Primary	586	80.8	0.0	17.6	0.5	1.2
Green Left Arrow signal indication with Protected Left on Green Arrow sign	Primary	564	72.1	0.0	24.9	0.9	2.1
Green Ball signal indication for left turn - no sign	Primary	538	79.0	0.0	17.6	1.5	1.9
Green Ball signal indication for left turn -Left Turn Yield on Green Ball sign	Primary	500	78.2	0.0	17.2	2.6	2.0

In general, the results of both comprehension surveys indicate that most of the Mexican drivers participating in the surveys understood the traffic control devices that were evaluated. About half of the devices had *correct* response percentages of over 80 percent. Messages that appear to be especially well understood include:

- The devices used to control right-of-way at an intersection, except for the Yield sign;
- The units used in signs conveying a speed message;
- The no-passing message of a yellow barrier line;
- The day/night message of the speed limit sign; and
- Messages conveyed by specific signs, including:
  - Do Not Enter sign,
  - Two Way Traffic sign,
  - Curve sign with Advisory Speed Plate sign,
  - Road Work Ahead sign,
  - One Way sign,
  - Stop for School Bus Loading or Unloading sign,
  - Hill sign,
  - School Crossing sign, and
  - Weight Limit 10 Tons sign.

However, the results identified some devices where there is a potential for improving comprehension. These devices or concepts are listed below.

- The correct meaning of the Yield sign was described by a much lower percentage of drivers (64 percent) than the Stop sign (99 percent) or the signal indications (98 percent);
- Drivers appeared to have some difficulty understanding the use of yellow to distinguish two-way traffic flow and that passing is permitted with a broken yellow centerline;
- Truck drivers had some difficulty describing the correct meanings of the signs related to hazardous cargo and truck weight;
- The difference in color between general warning and construction warning signs;
- Proper driving responses with respect to school buses; and
- Specific signs with lower comprehension levels:
  - Fasten Safety Belts
  - Right Lane Ends.

The Left Turn Yield on Green Ball sign appears to have little effect on driver understanding of the permitted left turn message associated with the green ball for a left turn. The Protected Left on Green Ball sign appears to confuse drivers more than improve understanding of the protected left turn message of the green arrow.

Truck driver responses to truck-related sign questions revealed several areas of deficiency. Understanding of the Low Clearance sign was relatively high, but they had difficulty relating the clearance shown in the sign to the height of their truck. They understood the weight limit sign, but had low comprehension levels of the Load Zoned Bridge and Weigh Station signs. They also had low comprehension levels of the signs related to hazardous cargo. Truck drivers had a much lower comprehension level of the day/night speed limit message (66 percent) than the other drivers participating in the survey (83 percent).

CHAPTER IV
INITIAL FINDINGS

The purpose of the first year of this research project was to evaluate the use of traffic control devices in border areas and to identify areas where improvements might be developed. The first-year activities were concentrated in three areas: information gathering, a critical incident survey, and driver comprehension surveys. Information about border area characteristics as they relate to traffic control devices was collected from the literature and telephone interviews of various individuals. Originally, the critical incident survey was intended to be the major effort of the first year. However, it was difficult to identify drivers who could provide the necessary type of information about critical incidents, and the information obtained from this effort was limited. As a result, the researchers accelerated the project schedule and conducted the comprehension surveys of traffic control devices during the first year.

In general, the information obtained during the first year of the project indicate that the existing system of traffic control devices used in the Texas border area functions well. There are some specific items where improvements should be considered. These improvements are described below.

- When to stop for a school bus appeared to confuse drivers. Potential treatments should concentrate on the bus and not signing;
- Handout information should be developed for Mexican truck drivers, with careful consideration to account for drivers that may be illiterate;
- Bilingual signing should be developed for the following applications:
  - Hazardous cargo signs,
  - Weight limits and weigh station signs,
  - Vertical clearances, including metric plaques for clearance dimensions, and
  - the Fasten Safety Belt sign;
- Explanatory signing should be developed for use on heavily traveled highways headed north from the border. These signs should explain the meaning of key traffic control device concepts. Specific concepts that should be addressed in these signs are:
  - Driver response to yellow pavement markings, and
  - Meaning of yellow barrier lines.
- The Mexican drivers participating in the survey appeared to have adequate understanding of the U.S. speed limit sign. Therefore, no changes are recommended for this sign at this time. However, additional evaluations should be conducted of the existing sign and the effectiveness of using signs (dual posting or bilingual) targeted to Mexican drivers.

For many of the comprehension limitations identified in the first year, there are limited engineering actions that could improve comprehension. In many cases, some form of driver education presents the most effective improvement strategy. Therefore, during the second year of this project, the researchers will develop a brochure that can be distributed at border crossings. This brochure will provide traffic control device information to address the weaknesses identified by the research.

Driver understanding of the Yield sign was significantly different than that of the other traffic control devices related to intersection right-of-way. The differences between the U.S. and Mexican Yield signs are minor, so the difference in comprehension levels may be attributable to some other factor, such as the difficulty in verbalizing the "yield" concept, the interpretation of the Spanish-language response by researchers, or a possible lack of understanding of the question.

CHAPTER V
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APPENDIX A

RESULTS OF PILOT COMPREHENSION SURVEY

This appendix presents the detailed results of the driver comprehension pilot survey administered on the international bridge between Reynosa, Tamaulipas (Mexico) and McAllen, Texas (U.S.) on May 10-11, 1996. The survey used a flashcard format, where a driver was shown an image of a traffic control device and asked to answer a question about the devices. The responses were recorded on a data form for later analysis. In analyzing the responses, the researchers classified each response as *correct*, *partially correct*, *incorrect*, or *not sure* according to the definitions given for each device on the following pages.

Table A-1 presents the demographic information for the pilot survey. Tables A-2 through A-28 present the results of the pilot survey.

Table A-1. Demographic Characteristics for the Pilot Survey

Characteristic		Frequency	Percent
Gender	Male	273	82.0%
	Female	51	15.3%
	N/R	9	2.7%
Age	< 25	33	9.9%
	25-55	247	74.2%
	>55	44	13.2%
	N/R	9	2.7%
Type of Vehicle	Passenger Car	189	56.8%
	Single Unit	14	4.2%
	Tractor/Trailer	109	32.7%
	Bus	7	2.1%
	N/R	14	4.2%

Note: N/R = not recorded

Table A-2. Pilot Survey Responses for Stop Sign

Stop	*What is this sign telling you?*		R1-1
Category	**Response**	**No.**	**Percent**
Correct	must come to a complete halt/stop/alto	68	98.6%
Partially Correct	no acceptable response	0	0.0%
Incorrect	all other responses	1	1.4%
Not Sure		0	0.0%
Total number of responses		69	100%

Table A-3. Pilot Survey Responses for Yield Sign

Yield	*What does this sign tell you?*		R1-2
Category	**Response**	**No.**	**Percent**
Correct	must give/cede/yield right-of-way to traffic on the other roadway	32	39.5%
Partially Correct	no acceptable response	0	0.0%
Incorrect	all other responses	33	40.7%
Not Sure		16	19.8%
Total number of responses		81	100%

Table A-4. Pilot Survey Responses for Do Not Enter Sign

Do Not Enter	*What does this sign indicate?*		R5-1
Category	**Response**	**No.**	**Percent**
Correct	you may not enter the roadway from this direction or wrong way	59	72.0%
Partially Correct	no acceptable responses	0	0.0%
Incorrect	all other responses	19	23.2%
Not Sure		4	4.9%
Total number of responses		82	100%

Table A-5. Pilot Survey Responses for Day/Night Speed Limit Sign

Speed Limit	*What does 70 mean on this sign?*			R2-1 & R2-3
Category	**Response**	**No.**	**Percent**	
Correct	maximum speed/maximum velocity/speed limit ***and*** units (70 miles per hour)	27	39.1%	
Partially Correct	maximum speed/maximum velocity/speed limit *or* units (70 miles per hour)	28	40.6%	
Incorrect	all other responses	11	15.9%	
Not Sure		3	4.3%	
Total number of responses		69	100%	

Table A-6. Pilot Survey Responses for Day/Night Truck Speed Limit Sign

Truck Speed Limit	*What does the 60 in this sign mean?*			R2-2a & R2-3
Category	**Response**	**No.**	**Percent**	
Correct	maximum speed/velocity for trucks ***and*** units (60 miles per hour)	9	11.4%	
Partially Correct	maximum speed/velocity for trucks *or* units (60 miles per hour)	30	38.0%	
Incorrect	all other responses	40	50.6%	
Not Sure		0	0.0%	
Total number of responses		79	100%	

Table A-7. Pilot Survey Responses for Mexican Speed Limit Sign

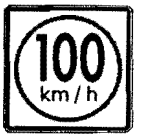
Mexican Speed Limit	*What does the 100 mean in this sign?*			----
Category	**Response**	**No.**	**Percent**	
Correct	maximum speed/velocity ***and*** units (100 kilometers per hour)	22	25.6%	
Partially Correct	maximum speed/velocity *or* units (100 kilometers per hour)	36	41.9%	
Incorrect	all other responses	28	32.6%	
Not Sure		0	0.0%	
Total number of responses		86	100%	

Table A-8. Pilot Survey Responses for One Way Sign

One Way	*What is this sign telling you?*			R6-1
Category	**Response**	**No.**	**Percent**	
Correct	all traffic moves in direction of arrow	2	2.4%	
Partially Correct	one-way	36	43.9%	
Incorrect	all other responses	39	47.6%	
Not Sure		5	6.1%	
Total number of responses		82	100%	

Table A-9. Pilot Survey Responses for Protected Left on Green Arrow Sign

Protected Left on Green Arrow	*If you want to turn left at an intersection, what is this sign telling you?*			R10-9
Category	**Response**	**No.**	**Percent**	
Correct	you have the right-of-way when the green arrow is on ***and*** you must yield right-of-way with the green ball	4	5.1%	
Partially Correct	you have the right-of-way when the green arrow is on ***or*** you must yield right-of-way with the green ball	12	15.2%	
Incorrect	all other responses	61	77.2%	
Not Sure		2	2.5%	
Total number of responses		79	100%	

Table A-10. Pilot Survey Responses for Left Turn Yield on Green Ball Sign

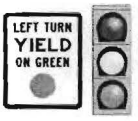
Left Turn Yield on Green Ball	*If you have a green signal, what is this sign telling you?*			R10-12
Category	**Response**	**No.**	**Percent**	
Correct	left turn okay on green ball ***and*** must after yielding right-of-way	1	1.5%	
Partially Correct	wait for green arrow ***or*** left turn okay on green ball after yielding right-of-way	9	13.8%	
Incorrect	all other responses	53	81.5%	
Not Sure		2	3.1%	
Total number of responses		65	100%	

Table A-11. Pilot Survey Responses for Two Way Left Turn Sign

Two Way Left Turn	*What is this sign telling you?*			R3-9b
Category	**Response**	**No.**	**Percent**	
Correct	center lane is used only for making left turns	3	4.5%	
Partially Correct	left turn or center lane used for turning	7	10.4%	
Incorrect	all other responses	56	83.6%	
Not Sure		1	1.5%	
Total number of responses		67	100%	

Table A-12. Pilot Survey Responses for Crossbuck Sign (Meaning)

Crossbuck	*What does this sign indicate?*			R15-1
Category	**Response**	**No.**	**Percent**	
Correct	railroad crossing ***and*** sign located at the tracks	0	0.0%	
Partially Correct	railroad crossing	47	68.1%	
Incorrect	all other responses	18	26.1%	
Not Sure		4	5.8%	
Total number of responses		69	100%	

Table A-13. Pilot Survey Responses for Crossbuck Sign (Location)

Crossbuck	*Where is this sign located?*			R15-1
Category	**Response**	**No.**	**Percent**	
Correct	at/on the tracks	30	50.0%	
Partially Correct	no acceptable response	0	0.0%	
Incorrect	all other responses	29	48.3%	
Not Sure		1	1.7%	
Total number of responses		60	100%	

Table A-14. Pilot Survey Responses for Stop for School Bus Loading or Unloading Sign

Stop for School Bus Loading or Unloading	*What should you do when you see this sign?*			R19-1
Category	**Response**	**No.**	**Percent**	
Correct	stop for school bus loading, unloading, or if the bus lights are flashing	0	0.0%	
Partially Correct	school bus	16	26.2%	
Incorrect	all other responses	45	73.8%	
Not Sure		0	0.0%	
Total number of responses		61	100%	

Table A-15. Pilot Survey Responses for Fasten Safety Belts Sign

Fasten Safety Belts	*What is this sign telling you?*			R19-8
Category	**Response**	**No.**	**Percent**	
Correct	must wear safety/seat belt ***and*** state law	9	10.6%	
Partially Correct	wear safety/seat belt	19	22.4%	
Incorrect	all other responses	12	14.1%	
Not Sure		45	52.9%	
Total number of responses		85	100%	

Table A-16. Pilot Survey Responses for Trucks Use Right Lane Sign

Trucks Use Right Lane	*What is this sign telling you?*			R4-5
Category	**Response**	**No.**	**Percent**	
Correct	applies to trucks ***and*** must be in right lane	37	50.0%	
Partially Correct	applies to trucks ***or*** must be in right lane	12	16.2%	
Incorrect	all other responses	13	17.6%	
Not Sure		12	16.2%	
Total number of responses		74	100%	

Table A-17. Pilot Survey Responses for Weight Limit Sign

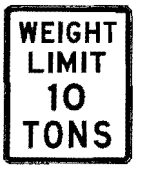
Weight Limit	*What does this sign indicate?*			R12-1
Category	**Response**	**No.**	**Percent**	
Correct	maximum weight ***and*** units (U.S. tons)	16	20.8%	
Partially Correct	maximum weight ***or*** units (U.S. tons)	26	33.8%	
Incorrect	all other responses	24	31.2%	
Not Sure		11	14.3%	
Total number of responses		77	100%	

Table A-18. Pilot Survey Responses for Hazardous Cargo Route Sign

Hazardous Cargo Route	*What is this sign telling you?*			R14-2
Category	**Response**	**No.**	**Percent**	
Correct	vehicles with hazardous cargo must follow sign	1	1.3%	
Partially Correct	no acceptable response	0	0.0%	
Incorrect	all other responses	12	15.0%	
Not Sure		67	83.8%	
Total number of responses		80	100%	

Table A-19. Pilot Survey Responses for Hazardous Cargo Prohibited Sign

Hazardous Cargo Prohibited	*What is this sign telling you?*			R14-3
Category	**Response**	**No.**	**Percent**	
Correct	vehicles with hazardous cargo are not allowed on this road	0	0.0%	
Partially Correct	either hazardous cargo ***or*** prohibited	2	2.9%	
Incorrect	all other responses	15	22.1%	
Not Sure		51	75.0%	
Total number of responses		68	100%	

Table A-20. Pilot Survey Responses for Hill Sign

Hill	*What does the 8% mean on this sign?*			W7-1 & W7-3
Category	**Response**	**No.**	**Percent**	
Correct	trucks ***and*** steep grade/downgrade	0	0.0%	
Partially Correct	trucks ***or*** steep grade/downgrade	26	36.1%	
Incorrect	all other responses	33	45.8%	
Not Sure		13	18.1%	
Total number of responses		72	100%	

Table A-21. Pilot Survey Responses for Clearance Sign

Clearance	*What does the 14 and 4 mean?*			W12-1T
Category	**Response**	**No.**	**Percent**	
Correct	vertical clearance/clear height ***and*** units (14 feet 4 inches)	21	24.4%	
Partially Correct	vertical clearance/clear height ***or*** units (14 feet 4 inches)	23	26.7%	
Incorrect	all other responses	23	26.7%	
Not Sure		19	22.1%	
Total number of responses		86	100%	

Table A-22. Pilot Survey Responses for Right Lane Ends Sign

Right Lane Ends	*What lane should you be in?*			W9-1
Category	**Response**	**No.**	**Percent**	
Correct	should be in, or move to, left lane	8	10.0%	
Partially Correct	no acceptable response	0	0.0%	
Incorrect	all other responses	57	71.3%	
Not Sure		15	18.8%	
Total number of responses		80	100%	

Table A-23. Pilot Survey Responses for Advisory Speed Plate Sign

Advisory Speed Plate	*What does the 35 mean in this sign?*			W1-2 & W13-1
Category	**Response**	**No.**	**Percent**	
Correct	recommended speed/maximum speed/speed limit ***and*** units (35 mph)	18	26.9%	
Partially Correct	recommended speed/maximum speed/speed limit ***or*** units (35 mph)	15	22.4%	
Incorrect	all other responses	33	49.3%	
Not Sure		1	1.5%	
Total number of responses		67	100%	

Table A-24. Pilot Survey Responses for School Bus Stop Ahead Sign

School Bus Stop Ahead	*What should you do when you see this sign?*			S3-1
Category	**Response**	**No.**	**Percent**	
Correct	watch for school bus ***or*** can't see school bus	1	1.3%	
Partially Correct	school bus	5	6.3%	
Incorrect	all other responses	70	88.6%	
Not Sure		3	3.8%	
Total number of responses		79	100%	

Table A-25. Pilot Survey Responses for Advanced Lane Closed Sign

Advanced Lane Closed	*What does this sign mean?*			CW20-5CR
Category	**Response**	**No.**	**Percent**	
Correct	right lane closed/ends ahead ***and*** move to left lane ***and*** construction zone	0	0.0%	
Partially Correct	right lane closed/ends ahead ***or*** move to left lane ***or*** construction zone	25	32.1%	
Incorrect	all other responses	42	53.8%	
Not Sure		11	14.1%	
Total number of responses		78	100%	

Table A-26. Pilot Survey Responses for Single Broken Yellow Center Line Sign

Single Broken Yellow Center Line	*What does the yellow stripe mean?*			Pavement Markings
Category	**Response**	**No.**	**Percent**	
Correct	two-way traffic ***and*** you are allowed to cross the line to pass	0	0.0%	
Partially Correct	two-way traffic ***or*** you are allowed to cross the line to pass	28	33.3%	
Incorrect	all other responses	48	57.1%	
Not Sure		8	9.5%	
Total number of responses		84	100%	

Table A-27. Pilot Survey Responses for No Passing Zone Markings Sign

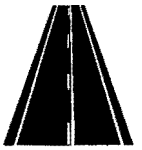
No Passing Zone Markings	*If you are traveling on the right lane, what do these yellow stripes mean?*			Pavement Markings
Category	**Response**	**No.**	**Percent**	
Correct	road is two-way traffic ***and*** you are not allowed to cross the solid yellow line to pass	0	0.0%	
Partially Correct	road is two-way traffic ***or*** you are not allowed to cross the solid yellow line to pass	23	31.9%	
Incorrect	all other responses	44	61.1%	
Not Sure		5	6.9%	
Total number of responses		72	100%	

Table A-28. Pilot Survey Responses for Double Solid White Line Sign

Double Solid White Line	*When can you cross these two white lines?*			Pavement Marking
Category	**Response**	**No.**	**Percent**	
Correct	never (except in case of emergency)	15	19.2%	
Partially Correct	no acceptable response	0	0.0%	
Incorrect	all other responses	57	73.1%	
Not Sure		6	7.7%	
Total number of responses		78	100%	

APPENDIX B

RESULTS OF FINAL COMPREHENSION SURVEY

This appendix presents the detailed results of the driver comprehension survey administered at international port crossings in El Paso and McAllen, Texas in August 1996. The survey used a flashcard format, where a driver was shown an image of a traffic control device and asked to answer a question about the devices. The responses were recorded on audio tape for later analysis. In analyzing the responses, the researchers classified each response as *correct*, *partially correct*, *incorrect*, *not sure*, or indeterminate according to the definitions given for each device on the following pages.

Table B-1 presents the demographic information for the final survey. Tables B-2 through B-5 present the results of the final survey.

Table B-1. Demographic Characteristics for the Final Survey

Characteristic		Frequency	Percent
Gender	Male	606	80.7%
	Female	145	19.3%
	N/R	8	1.1%
Age	< 25	48	9.4%
	25-55	452	88.3%
	>55	12	2.3%
	N/R	247	32.5%
Type of Vehicle	Passenger Car	576	78.7%
	Single Unit	37	5.1%
	Tractor/Trailer	103	14.1%
	Bus	14	1.9%
	Other/N/R	29	3.8%

Note: N/R = not recorded

Table B-2. Final Survey Results for Traffic Signal Indications and Left Turn Signal Signs

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does the red in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Stop at intersection or do not cross intersection	No acceptable response	97.7	0.0	2.0	0.0	1.0	601
	What does the yellow in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Be prepared to stop, slow down, use caution, or red light coming up	No acceptable response	97.7	0.5	2.0	0.2	0.2	599
	What does the green in this traffic signal mean? For all responses, if not answered already: a. What would you do if you saw this?	Allowed to enter or cross the intersection, have the right of way	No acceptable response	97.6	0.3	0.7	0.2	1.2	596
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	No, the arrow tells me to go	I don't think so	80.8	0.0	17.6	0.5	1.2	587
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	No, the arrow/sign tells me to go	I don't think so	72.1	0.0	24.9	0.9	2.1	563
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	Yes, the green tells me I have to yield	Maybe/I think so	79.0	0.0	17.6	1.5	1.9	534
	If you want to make a left turn, do you have to yield to traffic in the opposite direction?*	Yes, the green/sign tells me I have to yield	Maybe/I think so	78.2	0.0	17.2	2.6	2.0	499

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

Table B-3. Final Survey Results for Pavement Markings

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
 Broken Yellow Centerline Pavement Marking	Is this a one-way road or a two-way road?	Two-way road or cars going in both/opposing/ different directions	No acceptable response	72.2	0.0	25.3	1.5	1.0	593
 Broken Yellow Centerline Pavement Marking	Is the blue car allowed to pass the red car?	Yes, if there is enough room to pass safely.	Yes without identifying the safety element.	36.8	38.0	22.8	0.5	1.9	589
 No Passing Zone Pavement Markings	Is the blue car allowed to pass the red car?	No	No acceptable response	84.1	0.0	12.2	1.9	1.8	573
 Broken White Lane Line Pavement Marking	Is this a one-way road or a two-way road?	One-way or cars going in same direction	No acceptable response	51.5	0.0	45.2	2.6	0.8	505
 Broken White Lane Line Pavement Marking	Is the blue car allowed to pass the red car?	Yes	No acceptable response	81.8	0.0	14.3	1.4	2.4	490

Table B-4. Final Survey Results for Regulatory Signs

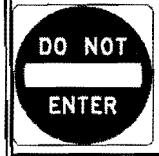
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If answer is only *STOP* a. What does this sign mean in Spanish? and/or b. What does *Stop* mean?	Must come to a complete halt (or stop or alto or pare)	No acceptable response	98.7	0.0	0.5	0.2	0.7	600
	What does this sign mean? If answer is only *YIELD* a. What does this sign mean in Spanish? and/or b. What does *Yield* mean?	Must give/cede/yield right-of-way (or cede el paso, de el paso) to traffic on the other roadway	No acceptable response	63.9	0.0	21.5	13.6	1.0	604
	What does this sign mean? For all responses: a. Is the speed in *kilometers per hour* or *miles per hour*?	Needs both concepts: maximum speed/ maximum velocity/speed limit ***and*** units (mph or miles)	Either concept: maximum speed/ maximum velocity/speed limit ***or*** units (mph or miles)	82.3	15.2	1.3	0.5	0.7	599
	b. Why are there two different numbers?	One is day speed and other is night (after dark) speed	No acceptable response	82.5	0.0	9.7	6.1	1.7	462
	What does this sign mean?	Must not enter the roadway from this direction, wrong way, or no entry	No acceptable responses	90.7	0.0	4.6	3.4	1.2	581
	What does this sign mean?	Right only or one-way	No acceptable response	83.3	0.0	13.8	1.6	1.3	558

Table B-4. Final Survey Results for Regulatory Signs (continued)

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

Table B-5. Final Survey Results for Warning Signs

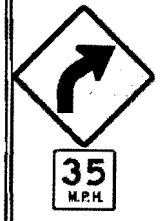
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	Road curves/turns/bends ***and*** recommended speed is 35 mph (must give units). Not speed limit or maximum speed	Either road curves/turns/bends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

Table B-6. Final Survey Results for Other Signs

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

Table B-7. Final Survey Results for Truck Related Signs

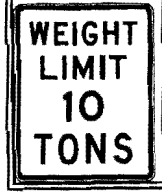
Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean? If the primary answer is "*SPEED LIMIT*" without specifying "*TRUCKS*": a. What types of vehicles must obey this speed limit?	Maximum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

Table B-7. Final Survey Results for Truck Related Signs (continued)

Device	Question	Correct Response Concept	Partially Correct Response Concept	Correct	Partially Correct	Incorrect	Not Sure	Unknown	Sample Size
	What does this sign mean?	There is a weight limit on a bridge ahead.	There is a weak bridge ahead	1.6	5.7	40.3	50.8	1.6	124
	If the answer indicates a "*BRIDGE AHEAD WITH A WEIGHT LIMIT*": a. What would you do if you saw this sign on the road?	Stop, turn around, or find another road if your truck weighs more than the limit.	No acceptable response	16.7	0.0	58.3	16.7	8.3	12
	What does this sign mean?	Weigh station open ***and*** trucks must stop to be weighed.	Weigh station open ***or*** trucks must stop to be weighed.	29.8	3.2	25.8	39.5	1.6	124
	If "*BASCULA*" is not used as a response: a. What is a weigh station?	Place where trucks are weighed	No acceptable response	79.3	0.0	10.3	6.9	3.5	29
	For all responses: b. Does this sign require you to go through the weigh station?	Yes	No acceptable response	83.3	0.0	6.7	6.7	3.3	30

Table B-7. Final Survey Results for Truck Related Signs (continued)

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