EVALUATION OF HIGHWAY SAFETY NEEDS OF SPECIAL POPULATION GROUPS – Phase I

A REPORT PRESENTED TO

THE SOUTHEASTERN TRANSPORTATION CENTER
UNIVERSITY OF TENNESSEE
ON

EVALUATION OF HIGHWAY SAFETY NEEDS OF SPECIAL POPULATION GROUPS – Phase I

By
Sunanda Dissanayake, Research Assistant,
J. John Lu, Ph.D., P.E., Assistant Professor,
Hua Tan, Research Assistant

Department of Civil and Environmental Engineering
and
Xuehao Chu, Ph.D., Research Associate,
Patricia Turner, Research Associate

Center for Urban Transportation Research

University of South Florida
Tampa, Florida 33620

October 1998

ABSTRACT

Although the United States has achieved dramatic progress in the past several decades in terms of highway safety, there is however still room for improvement. Each year, tens of thousands of people are killed and millions injured as a result of highway crashes, which in turn pose considerable economic loss to society. One area of highway safety that deserves further consideration is in relation to special population groups.

This project concentrates on the highway safety needs of six special population groups: older drivers, school aged children, young drivers, international tourists, new immigrants and people with disabilities. Ranking of highway safety importance was developed among the selected groups and critical highway safety issues and concerns were identified for each of the special population groups. These two basic tasks were accomplished by conducting two statewide surveys in which transportation professionals in the highway safety area were consulted and their views concerning the critical highway safety issues of the selected special population groups were identified. A multi criteria decision making approach was used in prioritizing the identified issues and concerns for each group. Identified critical safety issues were analyzed in detail after reviewing the available literature in this area, and countermeasures suggested for the critical issues and concerns. Wherever applicable, suggested countermeasures were summarized in the form of a matrix.

Models were also developed for each special population group so that fatality or crash rates could be projected until the end of the study horizon. Two sets of models were developed at the national level for the United States and also for the state of Florida.

The results of this project are expected to be extremely useful in increasing the highway safety of the selected groups as well as the general driving population. This study provides guidelines in addressing the most important issues first, thereby having the greatest impact on highway safety.

Key Words: Special Population Groups, Highway Safety, Projection Models, Critical Safety Issues, and Countermeasures

ACKNOWLEDGEMENT

This project was sponsored by the Southeastern Transportation Center (STC) at the University of Tennessee, which was established under the University Transportation Centers Program of U.S. Department of Transportation. The assistance and cooperation provided by the members of STC is greatly appreciated.

The authors would also like to express their sincere appreciation to Matthew Wey for the support given in editing the report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 Background

Safety performance of a transportation system is usually assessed by examining changes over time in the number and rate of deaths or injuries, and exposure to risk in each mode. By these standards, statistics clearly show that most modes have become safer over the past couple of decades, despite more intensive use. Much of the improvement results from use of innovations developed through research, education efforts by the transportation community, and improved emergency response and care. However, there are some risk factors hidden in the aggregates that continue to prompt concerns about transportation safety. Table 1.1 indicates a comparison of transportation fatalities to total and accidental deaths in United States for selected years. Transportation related accidents are decreasing as a percentage of total deaths, but have remained fairly constant at about half of all accidental deaths.

Out of all the transportation-related accidents, traffic or motor vehicle crashes account for more than 90 percent as illustrated in Table 1.2. The number of motor vehicle fatalities declined from a historical high of 54,589 in 1972 to a low of 39,250 in 1992. The fatality rate per 100 million vehicle-miles traveled declined from 4.74 in 1970 to 1.7 in 1996. These accomplishments can be attributed to increased traffic safety and injury campaigns such as public education on drinking and driving, implementation of occupant restraint laws, better roads and engineering, speed limit regulations, and technological advances. Despite these efforts, much more work remains in preventing the occurrence of highway crashes. Every year, millions of people are injured and tens of thousands are killed in highway crashes. The National Highway Traffic Safety Administration (NHTSA) estimated that the total economic cost of these crashes were $ 150.5 billion in 1994 and $137.5 billion in 1990 (Bureau of Transportation Statistics, 1997).

Table 1.1: Comparison of Transportation Fatalities to Total and Accidental Fatalities: Selected Years

Year	1970		1980		1992		1993	
	Number ('000)	%	Number ('000)	%	Number ('000)	%	Number ('000)	%
Resident population	203,904	-	227,225	-	255,039	-	257,800	-
Deaths from all causes	1,921	100	1,990	100	2,176	100	2.269	100
Accidental deaths	115	6.0	106	5.3	87	4.0	91	4.0
Transportation deaths	56	2.9	55	2.7	42	1.9	43	1.9
Share of transportation deaths	-	49.3	-	51.7	-	48.2	-	47.1

(Data Source: Transportation Statistics Annual Report 1997, Bureau of Transportation Statistics)

One area that demands further attention is the safety determination of special population groups. From examining current statistics, it is observed that certain population subsets are over represented in highway crashes. Table 1.3 shows driver crash and fatality rates per 100 Million Vehicle Miles of Travel (VMT) and per 1000 licensed drivers by age for 1996. Certain age groups experienced crash/fatality rates above the average values.

One reason promoting this occurrence could be that current highway designs and policies are not effectively reflecting the highway safety needs of such populations. In most cases, the design of highway facilities and traffic control devices, and corresponding policies and regulations are based on the average characteristics of all population groups. However, certain population subsets may have a greater probability in being involved in highway crashes. Unfortunately, studies conducted on the safety problems of special population groups are limited in number. If the safety concerns are identified through research, countermeasures could be determined to address each of the issues. The most suitable countermeasure could either be a policy change or a design change, depending on the issue that is being taken into consideration.

Table 1.2: Fatalities and Injuries by Transportation Mode

Year	Aviation (All types)	Motor Vehicles	Rail	Transit	Water (All types)	Pipeline
			Fatalities			
1985	1584	43,825	454	N/A	1247	33
1990	862	44,599	599	339	956	9
1991	983	41,508	586	300	984	14
1992	979	39,250	591	273	912	15
1993	803	40,150	653	281	910	17
1994	1050	40,716	611	320	853	22
1995	961	41,798	567	274	882	21
			Injuries			
1985	606	N/A	31,617	N/A	2929	126
1990	477	3,231,000	22,736	54,556	3997	76
1991	503	3,097,000	21,374	52,125	4077	98
1992	455	3,070,000	19,408	55,089	3850	118
1993	428	3,189,000	17,284	52,668	3719	112
1994	525	3,307,000	14,850	58,193	4263	1968
1995	462	3,507,000	12,546	56,991	5110	64

N/A- Not available

(Data Source: Transportation Statistics Annual Report 1997, Bureau of Transportation Statistics)

Among several subsets, six special population groups, experiencing highway safety concerns were selected for the purpose of this project. Selected special population groups include the elderly, international tourists, school aged children, young drivers, new immigrants, and persons with disabilities.

Table 1.3: Driver Crash Involvement and Fatality Rates by Age in 1996

Driver Age	Crash Involvement Rate (per 100 million VMT)	Fatality Rate (per 100 million VMT)	Crash Involvement Rate (per 1000 Licensed Drivers)	Fatality Rate (per 1000 Licensed Drivers)
15 - 19	**1938**	**3.2**	**175**	**0.29**
20 - 24	**886**	**2.0**	**103**	**0.23**
25 - 29	**635**	1.2	**82**	**0.15**
30 - 34	540	1.0	**72**	0.13
35 - 39	541	0.9	**70**	0.11
40 - 44	427	0.7	59	0.10
45 - 49	451	0.7	61	0.09
50 - 54	383	0.7	47	0.09
55 - 59	371	0.8	43	0.09
60 - 64	372	1.0	39	0.10
65 - 69	410	1.2	37	0.10
70 - 74	521	**1.8**	37	0.13
75 - 79	**654**	**2.9**	37	**0.17**
80 - 84	**782**	**5.2**	36	**0.24**
85 +	**912**	**7.9**	36	**0.31**
Total	*580*	*1.2*	*68*	*0.14*

Note: Bold values represent above average crash rates.

(Source: Research Note on "Crash Data and Rates for Age-Sex Groups of Drivers, 1996" NHTSA, January 1998)

1.2 Research Statement

The unique characteristics of certain special population groups, such as those studied in this research, have become important issues to the highway safety community. There is a great potential for reducing the number of traffic crashes (and economic loss) by addressing the safety issues relevant to these subsets. Once again, the number of studies addressing the individual highway safety needs of special population groups are limited. In approaching the safety problem from this viewpoint, it is first necessary to fully understand the unique characteristics associated with each special population group. It will be advantageous to rank the selected special population groups by their importance in terms of safety, allowing their corresponding critical issues and concerns to be identified. Projecting the magnitude of the problem until the end of the study period is extremely useful in selecting the critical groups. Once the critical safety issues are identified for each population subset, there is a need to investigate probable solutions or countermeasures to each of the issues.

Florida's warm tropical climate and recreational amenities attract many special populations, including senior citizens, immigrants, and tourists. As such, Florida offers an excellent environment to examine the roadway safety issues in association with these sub groups.

With the need for addressing the safety issues and concerns in terms of different population subsets, Southeastern Transportation Center at the University of Tennessee (established under University Transportation Centers Program of US Department of Transportation) funded the project "Evaluation of Highway Safety Needs of Special Population Groups" in May 1997. This study subsequently identifies the most critical special population groups and their corresponding critical safety issues along with the countermeasures in improving the identified issues.

1.3 Research Purposes and Objectives

The primary goal of this research is to identify critical safety issues of selected special population groups and then suggest countermeasures in the form of design or policy changes for the identified critical safety issues of the selected special population groups. The specific objectives of this study are:

1. To select specific population segments that have special highway safety issues and/or concerns,
2. To identify critical safety issues for each of the selected special population groups,
3. To perform quantitative analysis to evaluate the significance of safety of each special population group in terms of magnitude, severity of incidents, and future magnitudes due to population, socio-economic and behavior changes, and
4. To identify potential changes in public policy and engineering practices that are implemented to address the identified critical safety issues.

More specifically, this research concluded the following:

(1) The ranking of importance among the six selected special population groups:

The six special population groups considered in this study, older drivers, school-aged children, international tourists, young drivers, new immigrants, and people with disabilities were ranked according to their highway safety importance.

(2) The projections of the magnitude of the problem until Year 2010 are quantified in terms of number and/or rate of crashes:

Time series data on crash statistics obtained for each special population group were used to develop models that forecast the magnitude and severity of the problem. These models will enable the number and/or rate of crashes to be projected until the end of Year 2010.

(3) The determination of critical safety issues for each population group:

For each special population group, critical safety issues/concerns were ranked in accordance with the importance in terms of safety.

(4) The suggesting of possible countermeasures:

Countermeasures for each of the critical safety issues identified above were then suggested.

1.4 Outline of the Report

This report consists of eight chapters. Chapter 1 provides a comprehensive introduction to this report. Chapter 2 focuses on general details of the selected six special population groups and their significance described by using statistics. Chapter 3 explains the methodology employed in achieving the previously mentioned objectives, which is addressed through three subsections: projection models, surveys, and ranking model. The models developed for the projections of the problem magnitude are identified in Chapter 4. Two sets of models have been developed for Florida and the United States. Chapter 5 presents the results of the two surveys conducted and explains how the final ranking of issues and concerns were obtained. Chapter 6 addresses in detail some of the critical issues/concerns. Chapter 7 examines the countermeasures identified for each of the issue/concern for each special population group. Finally, Chapter 8 provides the conclusions and recommendations of this study.

CHAPTER 2: SELECTED GROUPS AND THEIR SIGNIFICANCE

Among several special population groups in existence, six groups that are known to experience critical highway safety issues were selected for this project. These special population groups include the elderly, international tourists, school-aged children, young drivers, new immigrants, and persons with disabilities. A brief description of the significance of each of the subsets is provided in the following paragraphs.

2.1 The Elderly

In 1900, 4 percent of the population in the United States lived to be 65 years old or more. In 1984, approximately 12 percent of the population were 65 or older. By the Year 2000, it is estimated that as much as 13 percent of the population in the United States will be over 65 years of age. Between the years 2020 and 2030, 20 percent of the population will be 65 years or older, even if birth rates stay low (TRB Special Report 218, 1988). According to the current trends, the majority of the elderly population relies on the automobile for most of their transportation needs. Although preserving the mobility of elderly is a primary concern, traffic safety statistics indicate that the elderly as a group experience a far greater risk of injury and fatality when using the roadways. Based on the statistics, the number of crashes involving elderly drivers are less than the average, since they drive less. On the other hand, the elderly are more likely to be killed or severely injured when involved in a crash. Decreased physical and mental capabilities of the elderly reduce their desire to maintain mobility through use of the automobile. This problem is even more acute when you consider that today's highway environment, in most cases, is based on the performance characteristics of the younger population.

The impact of the elderly is more significant in Florida than other states, since it has the highest percentage of elderly as shown in Table 2.1. Due to Florida's rich and diverse ethnic and cultural composition, it is likely that the percentage of retirees will continue to grow. Diversity is the factor that sets Florida's older population apart from that of most other states. Serving as a retirement magnet for the last couple of decades, Florida has attracted and continues to attract widely diverse ethnic groups from across the United States mainly for the shared reasons of climate, recreation and taxes.

Table 2.1: Top Ten States with Highest Percentages of Elderly as of July 1, 1995 and Their Resident Population

State	Resident Population		65 Years or Older Population	
	Total (Thousands)	Rank	Percentage	Rank
Florida	14,166	4	18.6	1
Pennsylvania	12,072	5	15.9	2
Rhode Island	990	43	15.7	3
West Virginia	1,793	34	15.3	4
Iowa	2,842	30	15.2	5
Arkansas	2,484	33	14.5	6
North Dakota	641	47	14.5	6
South Dakota	729	45	14.4	8
Connecticut	3,275	28	14.3	9
Massachusetts	6,074	13	14.2	10
United States	274,635		12.8	

(Adapted from the Department of Census Data, From http:\\www.census.gov)

The majority of the elderly in Florida are both physically and economically self-sufficient. This self-sufficiency is directly linked to economic resources, representing one of the state's largest revenue sources; Social Security and retirement benefits totaling approximately $30 billion annually (Florida Department of Health and Rehabilitative Services, 1989). In recognizing the economic impact of Florida's elderly, the state should endeavor to better living standards of the elderly in all aspects of their lives, especially transportation.

The number of motor vehicle crashes in Florida during 1996 by age group of drivers is illustrated in Figure 2.1. According to the figure, which depicts fatality rates per number of drivers and per miles driven, older drivers exhibit a disproportionate level of fatality in crashes. These data indicate the combined risk of being involved in a crash, suffering an injury, and dying in a crash. When an older driver is involved in a crash he or she has the greatest risk of being fatally injured.

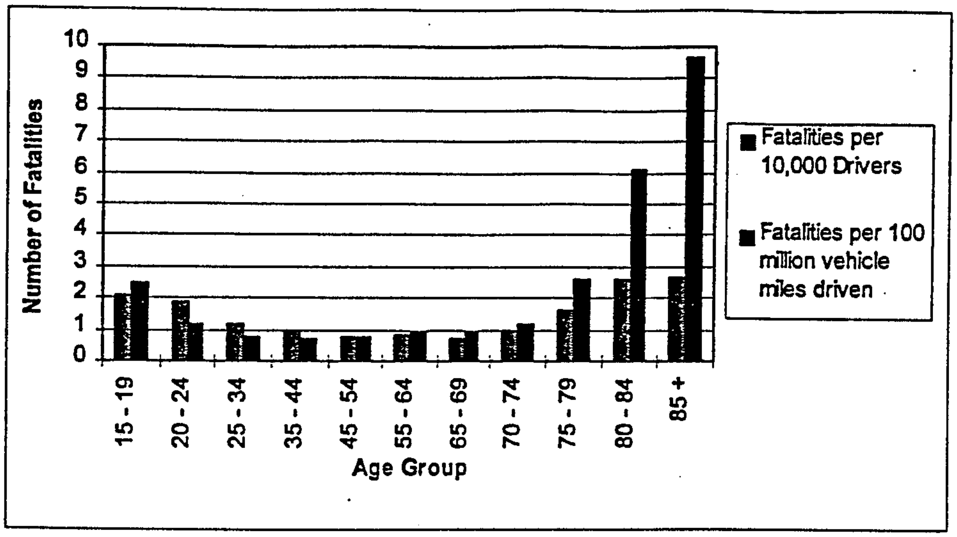

Figure 2.1: Driver Fatalities in Florida Crashes in 1993
(Source: Special Report on Driver Age Differences in Traffic Crashes, Florida Department of Highway Safety and Motor Vehicles, 1995)

As made evident by the high fatality rates per vehicle miles driven, the safe transportation of the elderly is a primary concern. In addition to studies conducted on accident rates, further research on behavioral and demand analysis issues needs to be conducted to improve roadway facility performance and design standards for the elderly. The aforementioned reasons necessitate the selection of older drivers as one of the special population groups requiring in depth analysis in terms of safety.

2.2 International Tourists

International tourists play an important role in the tourism industry of the United States. Florida attracts a considerable percentage of international tourists coming to U.S. Of the 22 million international tourists that came to U.S. in 1995, 19.2 % arrived in Florida. Statewide total taxable sales as a result of tourism/recreation accounted for $ 38 billion in 1996, which marks an increase of 7.3 % from the 1995 figure (Florida Tourism Industry Marketing Corporation, 1996).

The country of origin of international tourists traveling to Florida is listed in Table 2.2. There are significant differences between the transportation systems and signing practices used in the United States and that of other countries. Although traffic signs are uniform in U.S., international tourists may not be able to correctly interpret or properly respond to some traffic signs. Typical problems may include understanding of words and symbols, abbreviations and connotations of words, order of information, and cardinal directions.

Table 2.2: International Tourists to Florida and United States

Country	Total to Florida (Thousands)	Total to U.S. (Thousands)
Total	4,162	21,710
W. Europe	1,866	8,492
France	115	921
Germany	357	1,848
Italy	72	525
Netherlands	76	408
Norway	17	103
Spain	60	302
Sweden	35	219
Switzerland	66	396
United Kingdom	924	2,888
South America	1,225	2,449
Argentina	162	382
Brazil	406	838
Chile	65	152
Colombia	125	233
Ecuador	49	98
Peru	71	127
Venezuela	306	511
Central America	206	509
Other Countries/ Regions	580	13,750
Asia	161	6,616
Japan	118	4,598
Australia	16	423
Caribbean	466	1,043
Mexico	119	1,070

International tourists are usually unfamiliar with the area in which they are driving. The driver's familiarity with the road indicates the level of knowledge that he/she has with the road in question, including location of signs and exits, roadway surface and geometric conditions and so forth. A driver in an unfamiliar roadway may exhibit atypical driving behavior when faced with a situation that involves the perception and reaction of a sudden stimulus, such as in the cases of tail-gating, lane change, and inadequate gap acceptance. In addition, most international tourists are unfamiliar with U. S. driving laws and customs. Thus, international tourists may have a greater potential to be involved in traffic related incidents. Certain design and policy changes could potentially assist international tourists in guidance and navigational tasks that are necessary to safely traverse unfamiliar roadways. In consideration of the above factors, international tourists were selected as one of the population subsets requiring further consideration.

2.3 School Aged Children

Ensuring the safety of children en-route to and from school is a growing public concern in United States. Injuries and fatalities involving motor vehicles and children traveling to and from school, whether it be on foot, bicycle, or in school buses, generate intense media exposure (more than it is for any other special population group) and attracts the greatest public outcry to remedy the problem. A growing volume of literature points to four major contributing risk factors for children traveling to and from school: (1) longer walking and bicycling commutes; (2) increased traffic congestion and vehicular speeds along arterial routes during peak hours; (3) lack of crossing guards at major school zone intersections; and, (4) lack of motorist knowledge regarding school bus stopping laws.

According to a study conducted by the Center for Urban Transportation Research (CUTR) at University of South Florida, approximately 10,600 motorists illegally pass stopped school buses in Florida during a typical school day (Balts, 1998). During a 180-day school year, this amounts to about 1.9 million motorists illegally passing stopped school buses during a typical school year. The alarming number of illegal passes along with other factors raises several broad but important issues about motorists in Florida.

The most important concerns identified are motorist understanding of traffic control devices, including signalization and traffic signage, and their driving responsibilities as defined in certain state laws.

More research is needed to be conducted on the effectiveness of applying engineering techniques that are geared towards improving safety around schools. Furthermore, the existing guidance to assist the schools and communities in prioritizing safety improvements at intersections and streets along school commute corridors is found to be highly inadequate. Well-formulated policies with respect to this regard would also be helpful in improving the safety of school aged children. In particular, high vehicular speeds and volumes around schools are considered to be creating serious safety concerns for school aged children. Therefore, this study addressed that issue in detail along with many other considerations.

2.4 Young Drivers

The safety of young drivers is a high concern in almost every country; however, in the United States the problem is even more pronounced since licenses are generally granted one to two years earlier than most other countries. Young drivers, between the ages of 15 to 24 are getting injured and killed in traffic crashes at an alarming rate. In 1996, young drivers accounted for 24 percent of all traffic fatalities. Among all the age groups, young drivers are the most likely to be injured in crashes. On a per population basis, drivers under the age of 25 have the highest rate of involvement in fatal crashes than any other age group.

Observing the violations that lead to crashes can be helpful in shedding light on the behavior of young drivers. Table 2.3 gives the rate of citations issued in connection with crashes in Florida by age group for five most common violation types. Young drivers had the highest rate of receiving citations for each of the five types and disproportionately high rates for careless driving, traffic control, and lane change violations. The reasons underlying this situation may be attributed to driving inexperience, inadequate driving skills, poor driving judgment and decision making, risk taking behavior, and immaturity.

Combining these characteristics with alcohol use creates a particularly deadly mix. Investigations need to be carried out to find suitable design and policy changes that would assist in changing this alarming trend.

Table 2.3: Violations in Florida Crashes (per 1,000 drivers)

Age Group	Careless Driving	Failure to Yield	Alcohol Related	Traffic Control	Lane Change
15 - 24	7.33	4.87	1.01	0.85	0.42
25 - 69	2.35	2.03	0.88	0.31	0.20
70 +	1.27	2.96	0.11	0.33	0.16

(Data Source: Florida Department of Highway Safety and Motor vehicles)

2.5 People with Disabilities

Full participation of the disabled in society is essential for their independent living, overall well being, and economic-sufficiency. In addition, the independence of the elderly relieves society of the cost that would be used to take care of the elderly. For participation, they require access to the transportation system in a safe barrier-free way. The Americans with Disabilities Act (ADA) of 1990 was passed to increase access to public facilities for persons with disabilities.

The Census Bureau estimates that as of the end of 1994, about 54 million non-institutional persons were living in the U.S. with some sort of disability, 9.9 % with severe disability (NHTSA, 1997). Along with the increase of access to public facilities, persons with disabilities are being employed in increasing numbers. According to the same source, in 1995, 26.1 % (3.7 million) of those persons between the ages of 21 and 64 with severe disabilities were employed. In addition, 25.9 % of the 2.3 million long term users of mobility equipment (wheelchair, cane, walker clutches) in this age group were employed, amounting to 600,000 persons. Many people with disabilities need specific types of modifications made to and/or adaptive equipment added to their motor vehicles to meet their transportation needs. The safety of this population subset is of a different nature and requires careful consideration. Further research is needed to address the safety of their access to the transportation system.

2.6 New Immigrants

Immigrants are coming to United States in record numbers, many of whom come from vastly different environments than that of U.S. One component that differs from one country to the next is the transportation system. For many new immigrants walking or bicycling is the only familiar mode of transportation. Many of whom are not even familiar with these activities under very high vehicular volumes or speeds. Immigrants, who do not have long time exposure to safe driving habits, are forced to learn to drive for the first time. This learning process may be more difficult due to language barriers and cultural differences. Furthermore, many new immigrants learn to drive from friends or family members who may also lack the necessary experience. As a result of the barriers, differences, and difficulties, there is a strong need to investigate through research the safety concerns of new immigrants.

CHAPTER 3: METHODOLOGY

The methodology used in achieving the objectives mentioned in chapter 1 is discussed in the following sub-sections: projection models, surveys, and ranking models.

3.1 Introduction

The six special population groups identified for preliminary investigation were ranked in the order of importance in terms of highway safety. In the meanwhile, relevant issues and concerns were identified. As such, two surveys were conducted in which various transportation professionals in highway safety were asked to identify critical special population groups and their corresponding issues and concerns. Projection models used in estimating crash involvement and fatality rates for each population group were also developed from this research. The methodology used in each section is described below.

3.2 Projection Models

Two sets of projection models were developed: one for the state of Florida and the other at the national level. Time series data were obtained on the number of fatalities, injuries and crash involvement for each special population group. However, it was not possible to obtain accurate statistics for new immigrants and people with disabilities over an extended period of time. This is because most long form crash reports, which are predominately used in US, do not identify whether the person is a new immigrant. A similar situation was observed for people with disabilities. Due to this limitation, only four groups could be used in the projection model building process: older drivers, young drivers, school aged children and international tourists.

Along with the crash statistics, data were gathered for population size, number of licensed drivers, and number of vehicle miles driven by each population subset. This information was used to obtain different types of crash rates that were applied as dependent variables in the different projection models tested. The model that provided the best fit to the population group data was selected for projecting the magnitude of the problem in terms of the selected crash rate. To be consistent with the companion project conducted by University of Florida, which looked into the safety needs of transit, the study horizon was selected to conclude at the Year 2010. However, the purpose of the models was not to explain the occurrence of traffic crashes, but rather to simply express the crash rate of the considered special population group during the study period. Therefore, the time point within the study period or simply the year under consideration was selected as the dependent variable.

It was difficult to select a suitable period of data to be used in the model building process. Depending on the starting point in time chosen, different results were yielded. Thus, it was decided to develop the projection models using the longest period as possible, which spanned the history of FARS (Fatal Accident Reporting System) database. In some Florida models, the use of FARS was not justified because data were available for non-fatal crash statistics. Due to limited resources, this project did not analyze Florida's crash database to obtain the necessary statistics. Instead, information and data available in various publications were used in the projection model building process.

3.3 Surveys

Two surveys were conducted to identify critical special population groups and develop a final ranking among identified critical issues/concerns for all the population groups. The survey forms used in the first and second surveys are given in Appendix 1 and Appendix 2.

The first survey was intended to provide preliminary identification of critical special population groups and their corresponding issues and concerns. The second survey addressed a selected set of issues and concerns in detail, considering the effect of several important factors.

The first page of Survey 1 was used to obtain the ranking of importance among special population groups in terms of safety. Six special population groups were listed and the respondents were required to select one of six choices. The choices included a 'No Opinion' response and others that varied from 1 to 5, with 1 indicating 'Less Important' to 5 indicating 'More Important'. The remaining portion of the survey listed the identified issues and concerns of each special population group. Each of the identified issues/concerns required that a check mark be placed next too the opinion of the respondent. In addition, the respondents were given the opportunity to indicate their views by adding any sub group whom they consider as having safety concerns. Respondents could also add more safety issues/concerns for each population group, in addition to the ones listed in the questionnaire. This preliminary survey form was faxed to the respective individuals and follow-up phone calls were made to ensure a high return rate. The population targeted in the survey included traffic/transportation/safety engineers, law enforcement officers, administrative officers dealing with safety-related matters, university academics, and Community Traffic Safety Team (CTST) members in Florida. There is one CTST for every county in Florida, which works towards increasing the traffic safety in their county.

Based on the guidance achieved through the first survey, a second survey was conducted in a more detailed manner so that more information could be gathered about the selected safety issues/concerns. The possibility of making an evaluation of an issue was also taken into consideration when eliminating or adding some of the issues. The second survey form was also faxed to the same target population with only minor changes to the list (mostly due to employee transfers). Since this survey form required much more time and energy by the respondents, it was expected to have a lower return rate than that of the first survey. As a result, it was decided to mail a survey form along with a self addressed stamped envelope with the faxed survey form. This procedure was expected to provide a greater degree of flexibility for the respondents, thereby increasing the rate of return. Follow-up phone calls were also made at three stages: before faxing, after several days, and after the deadline mentioned in the cover letter. Further reminders were made for the non-responses if complete negative comments were not observed during the earlier phone calls.

Detailed information gathered by the second survey included the following:

- What impact do these issues have on crash/accident rates?
- How effective would it be to use roadway design changes to address each issue?
- How effective would it be to use policy changes to address each of these issues?
- How costly would it be to implement design or policy change to address each issue?
- How easy would it be to implement the change?

- How much of a priority to address each issue/concern?

For each of these factors, respondents were required to rate the factor on a scale of 1 to 5 for each of the issue/concern considered. The rating was expected to be based on the question of "how important the factor is in addressing each safety issue/concern." These ratings given by respondents were used to develop the final ranking model.

3.4 Ranking Model

The final ranking model was developed by evaluating the responses given in the second survey. Weights were assigned to each of these factors based on the significance and more accurate understanding about the critical safety issues were obtained by calculating an index for each issue. The higher the index, more important the issue would be. The magnitude of the index was used to rank the issues/concerns in a more accurate and quantitative way.

For a given population group, the index for each issue was:

$$Ij = \sum_{i=1}^{6} WiXij$$

Where; Ij = index for issue j

W_i = weight of the factor i

X_{ij} = mean ranking of issue j when considering factor i

i = factors being considered (1, 2, 3, 4, 5 and 6)

j = issues

The method of calculating the index for each of the issues under the special population groups is summarized in Table 3.1.

One of the most important and also difficult steps in this procedure was determining the weights. As such, weights were obtained by using two methods. The results of the two methods were compared to assess the reliability of the outcome. The two methods used were (1) assigning weights through a focus group, and (2) using the responses to the survey itself.

Table 3.1: Calculating the Index for Each Issue for Each Special Population Group

Issue	Attributes						Index
	i=1	I=2	i=3	i=i	……	i=6	
	w_i	w_2	w_3	w_i	……	w_6	
1	X_{11}	X_{21}	X_{31}	X_{I1}		X_{61}	I_1
2	X_{12}	X_{22}	X_{32}	X_{i2}		X_{62}	I_2
:							:
:.							:
j	X_{1j}	X_{2j}	X_{3j}	X_{ij}		X_{6i}	I_j
:	:	:					:

The focus group in the first method comprised of the research team who assigned weights to each of the factors depending on their personal opinion on importance. The mean of the weights given by the focus group was taken as the final weight for that factor used in estimating the indices. Even though it was possible to conduct a third survey to obtain the weights, it was decided that the research team had a better understanding and greater knowledge of each factor, and hence the importance of each factor in comparison. Weights were assigned for factors irrespective of the special population group and issues/concerns.

The second method used the mean of the rating given by the respondents to estimate the weights for each factor. This method enabled the weights to be assigned in terms of each special population group. Rankings were obtained by using these individual weights and also by considering the overall mean weight. The rankings obtained by the first method was compared with the results of the second method to assess the overall reliability of assigning weights to each of the factors.

CHAPTETR 4: PROJECTIONS OF THE PROBLEM MAGNITUDE

4.1 Introduction

Forecasting the safety performance of the highway system in terms of crash frequency or crash rate has several uses in legislation, courts and police enforcement, police deterrence, safety improvement measures, publicity and education programs, tax levies, and academics (Hakim et al, 1991). However, forecasting is not an easy task and the only thing certain about forecasting is its uncertainty. For instance, a set of independent variables included in a forecasting model may fit available statistics very well, but nonetheless may not explain safety performance in the future. One reason for this difficulty is that new independent variables may become relevant in the period following the model building process (Sivak, 1987). The effect of multi-collinearity among included independent variables may also contribute to a model's inability to explain variation in crash counts. The effect of several other variables not included in the models may also affect the uncertainty associated with forecasting models (Partyka, 1984).

Models developed in the past for forecasting highway safety performance were intent on trying to discover the causes for these changes. To counter the changes, researchers have employed several other types of dependent variables in the modeling process. The most commonly observed dependent variables are based on the number of fatalities, fatality rates per population, per registered vehicle, and vehicle miles traveled. Almost all of these models were used at macro level for total population of an entire country. The independent variables are diverse, prompting researchers to try different sets of variables. In one of the earliest models, Smeed used population and number of vehicles to obtain fatality rates (Smeed, 1949). Sivak tried to estimate fatalities per registered motor vehicle in each state by using homicide rate, suicide rate, fatality rate from non-traffic accidents, unemployment rate, personal income, density of physicians, alcohol consumption, motor vehicles per capita, road mileage per vehicle, .sex and age distribution of drivers, and attained education as independent variables (Sivak, 1983). However, only three variables, homicides per capita, proportion of drivers under 25 years of old, and fatality rate from non-traffic accidents were proven to be significant predictors. Partyka in 1984 used a set of economic parameters (number of employed workers, unemployed workers, and non-labor force) as independent variables to forecast the total number of fatalities. Some other variables employed in the past include fuel consumption, Gross National Product (GNP), vehicle length, average speed, traffic volume, traffic density, urban/rural travel, environmental factors, and combinations of the above. Irrespective of the type and number of independent variables used in the model, some researchers have conducted studies on the unsuccessfulness of the previously developed models (Sivak, 1987 and Partyka, 1991).

Another limitation to the models explained earlier, is that they need each independent variable to forecast for the year considered. The prediction for each of these variables is also equally uncertain, reducing the accuracy of the final prediction of safety performance. As such, models that do not require additional forecasting of independent variables are expected to perform better. Safety problems associated with different population subsets are not the same, because some groups are experiencing higher crash rates than the average population. For example, driver crash involvement and fatality rates by age group for a four-year period are given in Table 1.3 of Chapter 1. Teenage drivers aged 15 to 19 years have the highest crash involvement rates per 100 million vehicle miles traveled (more than three times the national average). A similar situation is illustrated in the fatality rate of older drivers. One underlying reason for this situation may be that current design and policy are not effectively representing the highway safety needs of the special population subsets. In most cases, the design of highway facilities, traffic control devices, and corresponding policies and regulations are based on the average characteristics of all population groups. Therefore, certain population subsets have a greater propensity to be involved in highway crashes, which is expected to vary with time.

Due to the previously mentioned considerations, it is more helpful to develop separate forecasting models for special population subsets, considering the time point (year) as the single independent variable. Such models will enable the critical groups to be identified at any time point within the study horizon. Depending upon the type of model, different crash rates were used as dependent variables. Fatality rates were considered for models at the national level, while different crash involvement and injury rates were taken into account for Florida models.

4.2 Methodology in Model Building Process

4.2.1 Data Sources

For national level models, the source of the crash statistics was the Fatal Accident Reporting System (FARS), developed and maintained by National Highway Traffic Safety Administration of U.S. Department of Transportation. At the state level, crash statistics were obtained from publications of Florida Department of Highway Safety and Motor Vehicles. Population estimates were obtained from two major sources, Statistical Abstract of the United States and Florida Statistical Abstract. Estimates on driver licensed population by age group were obtained from Federal Highway Administration publications on highway statistics. The Average Annual Vehicle Miles Traveled (AVMT) by population subset, for young and older drivers, was obtained using results from the Nationwide Personal Transportation Survey (NPTS). This survey has been conducted for years 1969, 1977, 1983, 1990, and most recently in 1995. For the intermediate years, it was assumed that vehicle miles traveled varied linearly with the time between the two end data points. However, caution must be taken in using the models developed using AVMT because of changes in survey methodologies at certain points.

4.2.2 The Approach

Two sets of models were developed: one at the national level and the other for the state of Florida. Among the several different model formats tested, the format that provided the best fit for all population subsets was of log linear type. A log linear model is obtained by taking the natural logarithm of the fatality or crash rate. The mathematical form of this model is given in Equation 1.

$$\mathrm{Log}_e(X) = a\,T + b \qquad (1)$$

$$X = e^{(a\,T + b)}$$

where, X = crash/fatality rate,

T = independent variable associated with the time, and

a, b = parameters to be determined.

This model, also referred to as negative exponential, has the advantage of having reducing gradients with time, which is most suitable for the safety situation of the country. Using this model format, regression analysis was performed on the historical crash data. In a study by Haight (1989), a similar time series model was used to forecast total annual traffic death totals. Haight's method was based on the assumption that the long-term trend of fatalities was a representation of two distinct parts, safety and exposure. As stated by Evans (1993), application of log linear models instead of simple linear regression heeds the warning of "Naive Extrapolation." In some cases linear regression may provide a good fit to the data, but may not avoid the unrealistic possibility of a zero crash rate within a certain time period.

4.3 RESULTS

4.3.1 Models At National Level

Three models were selected at the national level to forecast fatality rates for of older drivers, young drivers, and school-aged children. However, crash data were not available for the other special population groups. Crash rates of international tourists are not significant as they are spread throughout the country. The data range used in the model building process was extended from 1975 to 1996, resulting in 22 data points. As for young and older drivers, several different crash rates such as fatality rate per 100,000 population, per 100,000 licensed drivers, and per 100 million-vehicle miles traveled were considered as dependent variables. Summary of the negative exponential models developed for young and older drivers along with the corresponding statistical parameters are given in Tables 4.1 and 4.2. For each population subset, the model providing the best fit (highest R^2 value) was selected to be the forecasting model. The model that considered fatalities per 100 million vehicle miles traveled was the best model for young and older drivers. In order to consider the risk faced by school-aged children, fatality rate per 100,000 population was selected as the dependent variable. The resulting models are shown in Table 4.3.

TABLE 4.1: Models Developed for Older Drivers at the National Level

Dependent Variable (X)	The Model	t Value of		R^2 Value
		variable	constant	
Fatality Rate per 100 million vehicle miles traveled	$X = \exp[-0.01425(\text{Year} - 1974) + 1.14064]$	-10.8	65.8	0.854
Fatality Rate per 100,000 population	$X = \exp[-0.00715(\text{Year} - 1974) + 2.64]$	3.35	94.2	0.359
Fatality Rate per 100,000 licensed drivers	$X = \exp[-0.0087(\text{Year} - 1974) + 3.2405]$	-3.67	104.1	0.403

TABLE 4.2: Models Developed for Young Drivers at the National Level

Dependent Variable (X)	The Model	t Value of		R^2 Value
		variable	constant	
Fatality Rate per 100 million vehicle miles traveled	$X = \exp[-0.05733\,(\text{Year} - 1974) + 2.28204]$	-13.47	40.81	0.901
Fatality Rate per 100,000 population	$X = \exp[-0.01889\,(\text{Year} - 1974) + 3.7483]$	-7.84	118.4	0.754
Fatality Rate per 100,000 licensed drivers	$X = \exp[-0.01542\,(\text{Year} - 1974) + 4.0457]$	-5.99	119.68	0.642

Graphical illustrations of observed and estimated fatality rates of the three special population groups are given in Figures 4.1 through 4.3.

4.3.2 Models For the State of Florida

For the state of Florida, four separate forecasting models were developed for older drivers, international tourists, young drivers and school aged children. Unfortunately, crash data for new immigrants and people with disabilities were not available. When considering smaller sub divisions, the use of fatality rate as a dependent variable is not recommended since the number of fatalities may be too small and therefore subject to considerable random fluctuations. As such, injury or crash involvement rates were used in addition to fatality rate. The reliability of these crash statistics may be less, since fatalities and fatal crashes are better defined and more uniformly reported than injury crashes. The availability of historical data on injury crashes does not extend the period covered by FARS, causing models developed for Florida to be short term as compared to those developed on a national scale. Summary of the negative exponential forecasting models developed for Florida are given in Table 4.4. Similar to the national models, it was found that the model considering crash rate per 100 million vehicle miles traveled as the dependent variable was the best fitting model for both old and young driver population subsets. Several other models developed for this study were eliminated to save space. Once again, the models that best fit the available statistics were selected to be the forecasting models. Observed and estimated crash rates from selected forecasting models for the four population subsets are illustrated in Figures 4.4 through 4.7.

It was observed that the R^2 values for the Florida models were lower than those of the national models. Older driver models for Florida generated the lowest R^2 values. This is observed due to a sharp rise in crash rates for this population subset during the last several years. More research is necessary to determine suitable means of ensuring the highway safety for Florida's elderly drivers. This could be achieved by changing the operational characteristics of the highway system and/or making the necessary policy changes.

4.4 SUMMARY

The purpose of this study was to develop models to forecast fatality or crash rates for selected special population subsets at different time points within a specified study horizon. Hence, the independent variable was selected as the time elapsed from the base year. However, the models should not be used to project crash rates for an extended period of time. A maximum of 10-13 years (or until the end of year 2010) was the time period visualized by the authors in the developmental process of the models.

The forecasting models at the national level were found to be more accurate than the Florida models. The type of dependent variable employed in the models was the primary reason for the differences in model accuracy. The national level models used fatality rates, whereas the Florida models considered all levels of crash severity. Statistics based on fatalities tend to be more reliable because they are well defined and recorded in traffic crash reporting. In contrast to fatalities, injury and property damage only (PDO) crashes are not recorded on a consistent basis nor are they defined with the variation of time. In the young and older driver models, model accuracy is reduced due to the unreliability of AVMT data obtained from the NPTS. When changes in survey methodologies occur, it is difficult to determine if changes in travel patterns are genuine. As a result, the model accuracy for the two population subsets depended heavily on the reliability of the AVMT data.

The models developed in this study do not require the independent variable to be forecasted; rather the year for which the crash rate is to be estimated is substituted into the model. In comparison with models that require independent variables to be forecasted, uncertainty associated with the aforementioned models is less. Each additional prediction of an independent variable reduces the reliability of the final forecast.

The models developed for the population subsets will identify the groups having critical safety problems, and also provide an opportunity to check whether the same population subset will remain critical in the future. This identification will assist researchers in the area of highway safety to address the safety problems of most critical special population subsets.

TABLE 4.3: Summary of the Forecasting Models for School-Aged Children at the National Level

Dependent Variable (X)	The Model	t Value of		R^2 Value
		variable	Constant	
Fatality Rate per 100,000 population	(a). Aged 5 - 15 years: $X = \exp[-0.0446(\text{Year} - 1974) + 1.6659]$	-20.35	57.86	0.954
Fatality Rate per 100,000 population	(b) Aged less than 15 years: $X = \exp[-0.0476(\text{Year} - 1974) + 1.5611]$	-27.31	68.14	0.974

TABLE 4.4: Summary of the Forecasting Models for the State of Florida

Population Subset	N*	Dependent Variable (X)	The Model	t Value of		R^2 Value
				variable	Constant	
Older Drivers	12	Crash Involvement rate per million VMT	Aged 65 + years: X = exp [- 0.05738 (Year - 1984) + 1.20835]	-3.99	11.43	0.784
International Tourists	10	Crash Involvement rate per million pop.	X = exp [- 0.08072 (Year - 1985) + 7.09387]	-7.69	109.01	0.881
		Injury rate per million population	X = exp [- 0.06287 (Year - 1985) + 5.68259]	-6.82	99.39	0.853
Young Drivers	12	Fatality rate per million VMT	Aged 15 to 24 years: X = exp [- 0.07988 (Year - 1984) - 2.12825]	-8.22	-29.77	0.871
		Crash Involvement rate per million VMT	X = exp [- 0.08387 (Year - 1984) + 2.4454]	-6.29	24.92	0.834
School Aged Children	12	Injury rate per 100,000 population	(a). Aged 5 - 15 years: X = exp [- 0.02951 (Year - 1984) + 5.62511]	-6.51	168.68	0.809
(Non motorists)			(b) Aged less than 15 years: X = exp [- 0.03027 (Year - 1984) + 5.33544]	-6.44	154.31	0.806

* - Number of years of data considered in the model building process

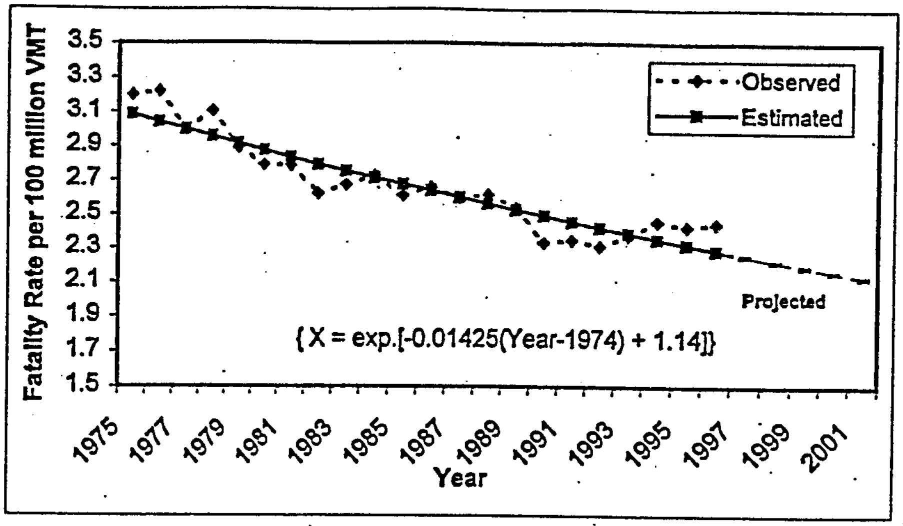

Figure 4.1: Observed and Estimated Fatality Rates for Older Drivers- U.S

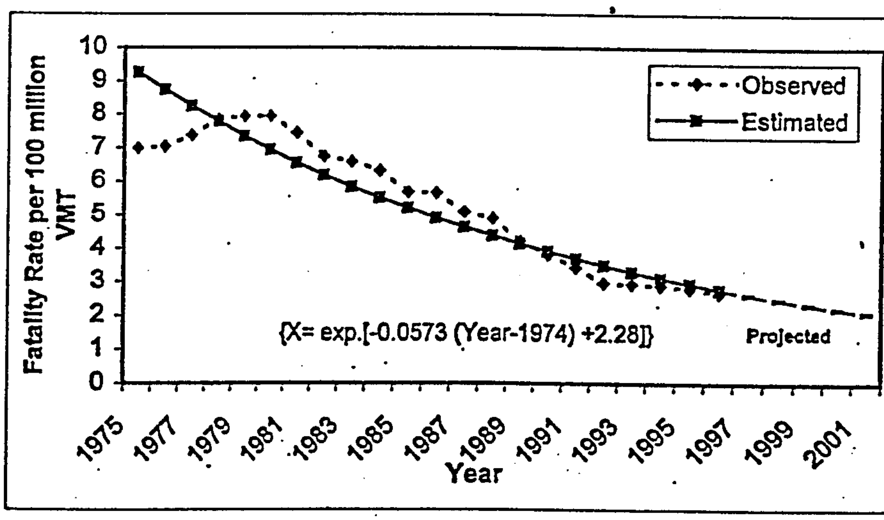

Figure 4.2: Observed and Estimated Fatality Rates for Young Drivers- U.S

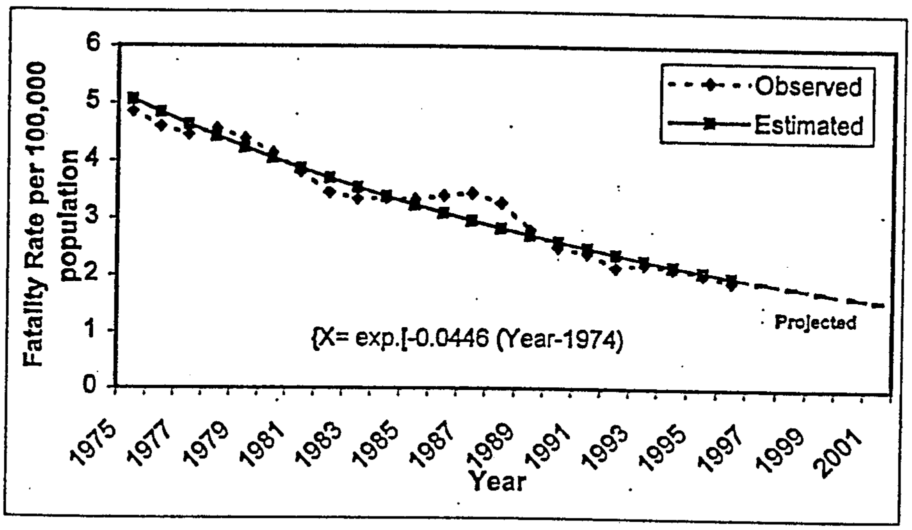

Figure 4.3: Observed and Estimated Fatality Rates for School Children- U.S

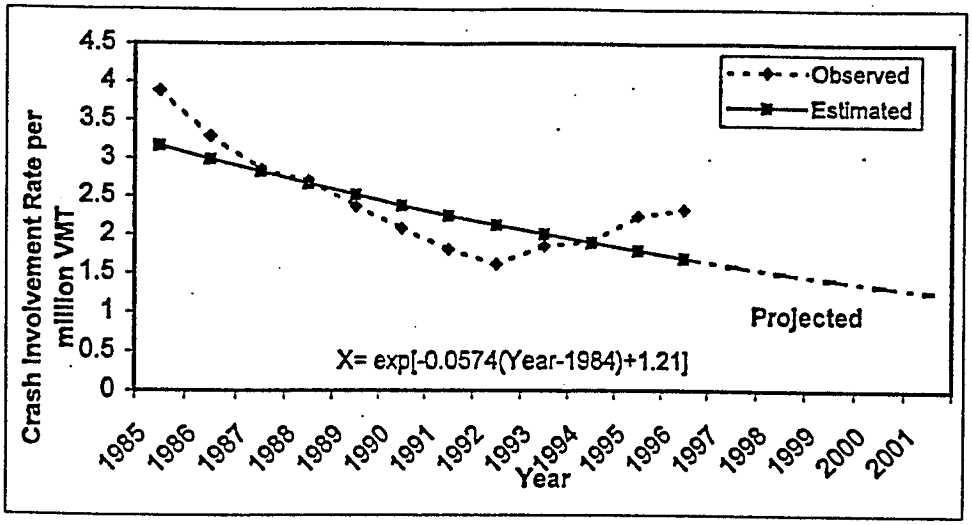

Figure 4.4: Observed and Estimated Fatality Rates for Older Drivers - FL

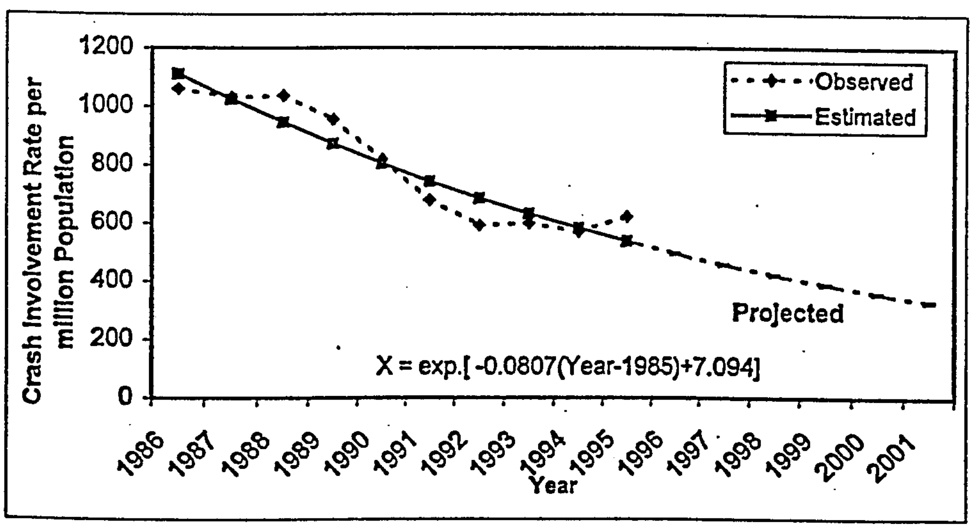

Figure 4.5: Observed and Estimated Fatality Rates for International Tourists - FL

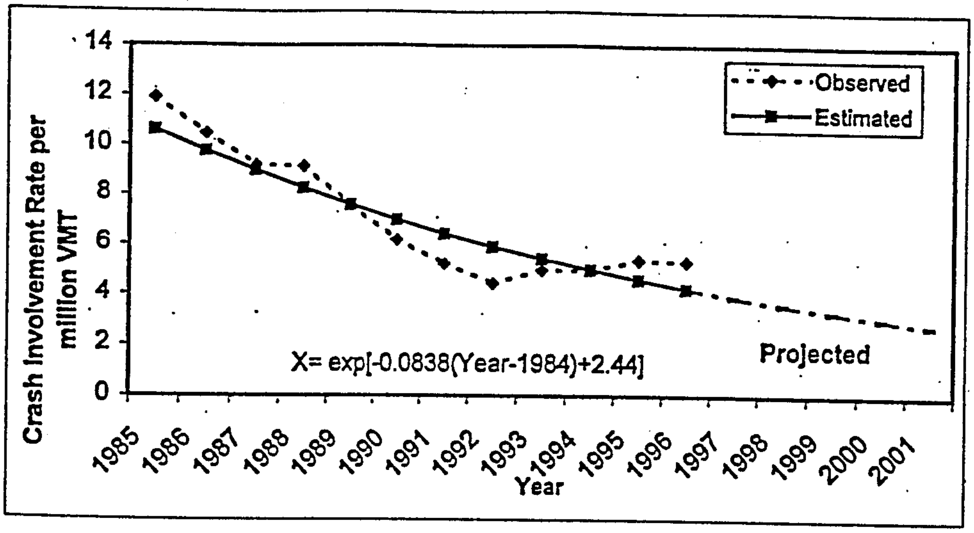

Figure 4.6: Observed and Estimated Fatality Rates for Young Drivers - FL

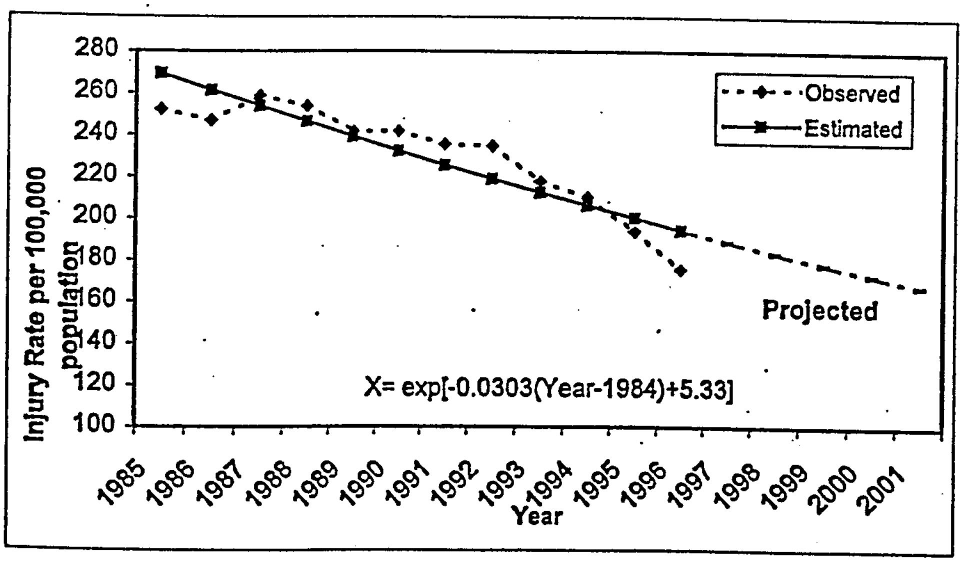

Figure 4.7: Observed and Estimated Fatality Rates for School Children (5-15 yrs) - FL

CHAPTER 5: IDENTIFICATION OF CRITICAL GROUPS AND ISSUES/ CONCERNS

1.1 Introduction

Identification of critical special population groups and their corresponding highway safety issues/concerns was performed using the responses obtained in both of the previously mentioned surveys. The rate of response for the each survey is given in Table 5.1.

Table 5.1: Basic Statistics about Survey Responses

Survey	Number of Survey Forms Sent Out	Number of Survey Forms Returned	Response Rate
Survey 1	149	92	62 %
Survey 2	164	72	44 %

The composition of survey respondents with respect to their profession is shown in Table 5.2. Apparent from this table, the number of respondents that could not be identified by profession increased in Survey 2. The reason for this situation was that the mail-back option was made available to the respondents, which made it difficult to personally identify the respondent's profession. In the first survey, most of the respondents faxed the survey form, making it possible to identify the respondent through a matching of fax numbers. As expected, the return rate was low in the second survey due to the in-depth nature of the survey, which required respondents to spend more time and energy in completing the survey form.

The same professionals were consulted in both surveys, except for the case of an employee transfer where an additional person was surveyed. Therefore, it was expected that the results of the two surveys would be comparable to one another.

Table 5.2: Composition of Survey Respondents

Profession	Number (Percentage)	
	Survey 1	Survey 2
Engineers (Traffic, Transportation, Safety etc.)	52 (56.5 %)	29 (40.3 %)
Law Enforcement Officers (Police, Highway Patrol etc.)	13 (14.1 %)	11 (15.3 %)
Administrative Officers in Safety Area	11 (12.0 %)	7 (9.7 %)
University Academics	5 (5.4 %)	2 (2.8 %)
Others and Unknown	11 (12 %)	23 (31.9 %)

5.2 Preliminary Identification of Special Population Groups and Issues

The mean ratings as provided by the respondents in Survey 1, were used to identify and rank critical special population groups by highway safety importance. The ranking together with the mean rating and standard deviation is listed in Table 5.3. Rankings of the identified highway safety issues are given in Table 5.4. It is worthwhile mentioning that the ranking of Survey 1 issues and concerns was not considered to be accurate enough to address or implement a corresponding countermeasure. Rather than emphasize one single factor, a multi criterion approach was taken whereby a second survey form was designed specifically to suit that purpose. It took into account several different attributes that were expected to be important in reaching the final decision about addressing of the issues.

In light of the opportunity for respondents to express their views on safety related matters, several other populations subsets such as pedestrians and cyclists were named. However, these subsets were not subjected to further investigation in this study.

Table 5.3: Ranking of Importance among Selected Population Groups

Ranking	Special Population Group	Index	Std. Deviation
1	Older Drivers	4.28	1.07
2	School Aged Children	4.12	0.87
3	Young Drivers	4.00	1.01
4	Disabled People	3.53	1.23
5	International Tourists	3.35	1.28
6	New Immigrants	3.12	1.06

Table 5.4: Order of Importance of Safety Issues/Concerns

(a) Older Drivers

Ranking	Issue/Concern	Index
1	Night time visibility	4.53
2	Perception reaction time	4.23
3	Dimensions of signs and lettering	3.84
4	Location of the traffic signs	3.53
5	Gap acceptance capabilities at the stop controlled intersections	3.43
6	Difficulties in understanding the changeable highway messages	3.32
7	Deficiencies in driving knowledge	3.09
8	Start-up lost time and saturation headway at signalized intersections	2.92

(b) School Aged Children

Ranking	Issue/Concern	Index
1	High vehicular speeds in and around school zones	4.27
2	High traffic volumes around schools	4.05
3	Lack of pick-up and drop-off zones, sidewalks, traffic lights etc.	3.70
4	Lack of traffic and bicycle safety education programs	3.60
5	Lack of proper signage, signals etc.	3.60
6	Not enough school crossing guards	3.23
7	Lack of traffic calming devices such as speed humps, raised pedestrian medians etc.	2.98

(c) International Tourists

Ranking	Issue/Concern	Index
1	Confusion of traffic guide signs	3.83
2	Unfamiliarity with roadways	3.83
3	Recognition of traffic signs	3.55
4	Unfamiliarity with the driving system	3.25

(d) Young Drivers

Ranking	Issue/Concern	Index
1	Risk taking behavior/aggressiveness	4.26
2	Speeding	4.17
3	General recklessness	4.10
4	Impaired Driving(Alcohol and Drugs)	4.09
5	General lack of driving experience	4.08
6	Lack of driver training programs	3.73
7	Lack of safety belt use	3.71
8	Teen cruising	2.81

(e) People with Disabilities

Ranking	Issue/Concern	Index
1	Lack of policies for recalling driving licenses from people with progressive disabilities	4.01
2	Unsafe access to transportation facilities	3.73
3	Lack of standards for vehicle modifications necessary for disabled	3.44
4	Lack of crossing devices for blind people	3.39
5	Default designs in roadways and intersections	3.28

(f) New Immigrants

Ranking	Issue/Concern	Index
1	Inadequate/ Improper driving education	3.52
2	Language barriers	3.51
3	Unfamiliarity with the driving system	3.40
4	Differences in the transportation system	3.30
5	Cultural differences	3.16

5.3 Final Ranking of Issues/Concerns

The final ranking of issues was based on the results of the second survey, which considered six different attributes (factors). These factors included impact on crash rates, effectiveness of applying roadway design changes, effectiveness of applying policy changes, cost associated with the change, ease of implementing the change, and priority to address the issue. By applying weights to the individual factor ratings for each issue/concern, the index explained in the previous chapter was calculated for each special population group. The weights estimated by considering three different methods are given in Table 5.5. One set of weights was obtained through a focus group, while the other two sets were achieved by considering the responses in Survey 2. In two sets of models, weights were used for all of the special population groups without differentiating between the groups. However in the third set, weights were estimated for each factor in each special population group.

Three sets of weights were applied to the mean ratings and the issues were ranked in order of safety importance. The resultant rankings are listed in Table 5.6. It can be observed that for the special population groups of international tourists and people with disabilities the rankings are exactly the same, irrespective of the set of weights used. For other groups the ranking changes slightly, but nevertheless the major priorities remain the same. Hence, it can be concluded that the selected sets of weights did not significantly affect the ranking results.

5.4 Summary

Obtaining a considerably high response rate from the surveys was a challenging task in this project. This was more evident in the case of Survey 2, where a considerable amount of time and effort was expected from the respondent. As such, the achieved response rates were considered to be satisfactory. A concern arises about the consistency and compatibility of the two surveys. Since the final ranking of issues was based on the second survey this may not pose any negative implications on the results.

Three different types of weights were applied to the factors in Survey 2 to obtain the rankings for each special population group. It was observed that a similar ranking of the issues was achieved irrespective of the set of weights employed. This could be considered as an indication of the reliability of the ranking for each group.

Table 5.5: Estimated Weights for Factors given In Survey 2

Factor	Weights (based on a scale of 1 -10)		
	Through the Focus Group	Through the Responses to the Survey	
		For all groups	For Individual Special Population Group
1. Impact on crash/accident rate	8.5	7.3	Older Drivers - 7.2 ; International Tourists - 7.2 School Aged Children - 7.4 ; Young Drivers - 8.4 New Immigrants - 7.2 ; People with Disabilities - 6.2
2. Effectiveness of using roadway design changes	5.0	4.9	Older Drivers - 5.8 ; International Tourists - 4.6 School Aged Children - 6.4 ; Young Drivers - 3.2 New Immigrants - 4.0 ; People with Disabilities - 5.2
3. Effectiveness of applying policy changes	5.	6.1	Older Drivers - 5.2 ; International Tourists - 5.6 School Aged Children - 6.4 ; Young Drivers - 6.6 New Immigrants - 6.0 ; People with Disabilities - 6.8
4. Cost associated with implementing design/policy change	6.5	6.6	Older Drivers - 7.2 ; International Tourists - 6.6 School Aged Children - 6.2 ; Young Drivers - 6.0 New Immigrants - 6.4 ; People with Disabilities - 7.0
5. Ease of implementing the change	6.5	5.1	Older Drivers - 5.2 ; International Tourists - 5.0 School Aged Children - 5.8 ; Young Drivers - 4.8 New Immigrants - 4.8 ; People with Disabilities - 5.2
6. Priority to address the issue	3	6.8	Older Drivers - 6.4 ; International Tourists - 6.0 School Aged Children - 7.6 ; Young Drivers - 8.2 New Immigrants - 6.2 ; People with Disabilities - 6.4

Table 5.6: Final Rankings of Issues/Concerns Through Different Sets of Weights

(a) Older Drivers

Issue/Concern	Ranking		
	Common Weights through Focus Group	Common Weights through Survey 2	Individual Weights through Survey 2
1. Night time visibility	2	2	2
2. Driving in congestion	9	7	7
3. Freeway driving	8	9	9
4. Maneuvering curves	7	8	8
5. Deficiencies in driving knowledge	5	5	5
6. Location and size of traffic signs and lettering	1	1	1
7. Perception-reaction time	4	3	3
8. Gap acceptance	3	4	4
9. Narrow lanes	6	6	6

(b) School Aged Children

Issue/Concern	Ranking		
	Common Weights through Focus Group	Common Weights through Survey 2	Individual Weights through Survey 2
1. High traffic volumes around schools	9	9	9
2. Speeding in and around school zones	4	3	3
3. Lack of drop-off and pick-up zones	5	5	5
4. Lack of traffic calming devices	8	8	8
5. Lack of proper signage and traffic signals	6	6	6
6. Lack of sidewalks and bike routes	1	1	1
7. Lack of traffic and bicycle safety programs	3	4	4
8. Lack of school crossing guards	7	7	7
9. Lack of parental guidance	2	2	2

(c) International Tourists

Issue/Concern	Ranking		
	Common Weights through Focus Group	Common Weights through Survey 2	Individual Weights through Survey 2
1. Unfamiliar with roadway system	3	3	3
2. Unfamiliar with driving system	5	5	5
3. Difficulty in recognizing and understanding traffic signs	1	1	1
4. Lack of information about driving laws and customs in US	2	2	2
5. Confusion in translating English into metric distance on signs	4	4	4

(d) Young Drivers

Issue/Concern	Ranking		
	Common Weights through Focus Group	Common Weights through Survey 2	Individual Weights through Survey 2
1. Lack of Driving Experience	3	5	4
2. Reckless/aggressive driving	2	2	2
3. Speeding	1	1	1
4. Impaired driving	5	3	3
5. Lack of safety restraint use	4	4	5
6. Lack of driver training programs	6	6	6
7. Immaturity	7	7	7

(e) People with Disabilities

Issue/Concern	Ranking		
	Common Weights through Focus Group	Common Weights through Survey 2	Individual Weights through Survey 2
1. Unsafe access to transportation facilities	3	3	3
2. Lack of policies for issuing and recalling driver's licenses	1	1	1
3. Lack of standards for vehicle modifications required for disabled	2	2	2
4. Faulty designs in roadways and intersections	4	4	4

(f) New Immigrants

Issue/Concern	Ranking		
	Common Weights through Focus Group	Common Weights through Survey 2	Individual Weights through Survey 2
1. Unfamiliar with traffic laws and regulations	1	1	1
2. Unfamiliar with vehicle systems	5	7	5
3. Unfamiliar with road systems	2	4	2
4. Lack of driver education	4	3	4
5. Lack of safety education	3	2	3
6. Language barriers	6	5	6
7. Cultural differences	7	6	7

CHAPTER 6: ANALYSIS OF SOME CRITICAL ISSUES/CONCERNS

The critical issues and concerns identified through the use of the ranking model in Chapter 5 are analyzed in this section. An extensive literature search was performed to obtain past studies that addressed each area of safety concern. Accordingly, this analysis is based on the information ascertained in those studies. The details and summary tables provided whenever possible render a detailed investigation into each issue and concern.

6.1 Older Drivers

In terms of highway safety, older drivers were consistently ranked first. Some of the issues/concerns identified in several past studies relating to older drivers are discussed in this section.

6.1.1 Location and Size of Traffic Signs and Lettering

The issue of location, size, and lettering of traffic signs received the highest priority among all the issues/concerns selected in the second survey. The size and location of both traffic signs and lettering should be in such a way that not only the average population, but also older drivers, who generally experience decreased mental and physical capabilities, have sufficient time to respond to a required action.

A study conducted in 1992 attempted to determine if different alphabet styles/fonts other than the existing standard letter series specified in the Manual on Uniform Traffic Control Devices on Highways and Streets (MUTCD) would increase legibility (Tan, 1992). The measure of effectiveness used to determine the performance of a sign was legibility distance, which was defined as the farthest distance at which a sign could be read. The three types of signs used in the study were regulatory, warning, and guide signs. Legibility distances were measured for two age groups, older (65 years and older) and younger (16-25 years). Table 6.1 gives the mean legibility distances of different fonts (in terms of legibility per inch of letter height) for the two age groups categorized by gender.

Table 6.1: Mean Font Legibility Distances in ft/in

(a) For Regulatory Signs

Subjects	Mean Legibility Distance (ft/in)				
	Letter Series C	Serif Gothic	Helvetica	Vag Rounded	Dot matrix
Older Females	54	50	50	57	34
Older Males	57	48	57	59	34
Younger Females	66	62	66	70	49
Younger Males	85	78	83	86	64
All Subjects	65	60	64	68	45

(b) For Warning Signs

Subjects	Mean Legibility Distance (ft/in)				
	Letter Series C	Serif Gothic	Helvetica	Vag Rounded	Dot matrix
Older Females	72	71	71	76	54
Older Males	76	77	79	80	56
Younger Females	85	86	87	89	75
Younger Males	97	97	102	103	84
All Subjects	82	83	85	87	67

(c) For Guide Signs

Subjects	Mean Legibility Distance (ft/in)				
	Letter Series C	Serif Gothic	Helvetica	Vag Rounded	Dot matrix
Older Females	47	46	48	46	46
Older Males	50	48	49	47	50
Younger Females	51	51	52	51	52
Younger Males	58	55	60	57	58
All Subjects	51	50	52	50	52

An analysis of variance (ANOVA) performed on the data indicated that for all three types of signs the legibility distances were significantly different for age and gender at the 95 percent confidence level. The results show that older subjects performed substantially worse than their younger counterparts and males fared better than females. However, most of the legibility values were greater than the 50-ft/in standard. This is the value utilized in current highway sign design that assumes a legibility distance of 50 feet per one inch of letter height. As such, the study suggested retaining the standard highway alphabet letter series.

A study conducted in 1991 examined the trade-off between traffic sign size and background material on legibility and conspicuity distances (Khavanin and Schwab, 1991). Three different sign sizes and two retro-reflective materials were tested by 48 subjects of the ages 60 and older. The legibility distances observed during daytime for three different sign sizes are given in Table 6.2. As expected, the statistical analysis indicated that the legibility distance was negatively correlated with age and reaction time.

Table 6.2: Daytime Legibility Distances (feet) - Bump Signs

Sign Size	Mean	STD	Min	Max	Median
18 inch	222	65.4	85	441	220
24 inch	288	82.0	169	569	294
30 inch	338	83.4	127	524	340

The nighttime legibility distances observed during the same study for the two different retro-reflective materials, referred to as types II and III, are given in Table 6.3. As indicated, legibility distances increase considerably with the size of the sign. Although this effect is not as pronounced during the daytime. The results of this study suggested that the standard of 50 ft per inch of letter height used for highway guide signs was not adequate for older drivers.

Table 6.3: Nighttime Legibility Distances (feet) - Bump Signs

Size(in), Type	Mean	STD	Min	Max	Median
18, II	132	36.4	57	207	133
24, II	186	44.2	85	267	188
30, II	229	59.2	87	339	235
18, III	142	41.4	57	251	141
24, III	215	59.7	84	350	216
30, III	249	64.5	90	388	252

6.1.2 Nighttime Visibility

In terms of safety for older drivers, nighttime visibility received the second greatest emphasis. The second study indicated that nighttime legibility distances are considerably smaller than daytime legibility distances for older drivers (Khavanin and Schwab, 1991).

Benekohal et al. conducted a statewide study on highway design and traffic operation needs of older drivers in Illinois (Benekohal et al., 1994). A total of 664 senior drivers responded to a mail survey that asked questions about the importance of present day highway design features and difficulty of driving activities as compared to 10 years ago. The majority of the elderly respondents indicated that driving at night was the most difficult driving task. As for the importance of highway design features, intersection lighting was identified to be of primary concern. Examination of these two factors will explain the problem of nighttime visibility experienced by older drivers. The driving activities that have become more difficult and the design features that became more important together with their corresponding percentages are listed in Table 6.4 and 6.5 respectively.

Statistical tests were carried out to analyze the driving difficulties not only by age but also by gender. Significant gender differences were observed for driving at night. Female drivers reported nighttime driving more difficult than male drivers. As far as the four age groups

(66-68, 69-72, 73-76, and 77+) considered, nighttime driving has become particularly difficult for the 77+ age group, more than for any other age group.

Table 6.4: Proportion of Senior Drivers Who Indicated that Driving Activities Became More Difficult Now Compared to 10 Years Ago

Driving Activities	Percentage
Driving at Night	62.17
Driving in Heavy Traffic	52.16
Driving at High Speeds on Freeways	31.68
Driving in Construction Zones	28.5
Reading Street Signs in Town	26.79
Reading Signs on Freeways	23.46
Driving Across an Intersection	21.17
Finding Beginning of Left Turn Lane	20.37
Making Left Turns	19.01
Following Pavement Markings	16.85
Driving in Daytime	13.3
Responding to Traffic Signals	11.57

Table 6.5: Proportion of Senior Drivers Who Indicated that Highway Features Became More Difficult Now Compared to 10 Years Ago

Highway Design Features	Percentage
Lighting at Intersections	61.69
Pavement Markings at Intersections	56.57
Number of Left Turn Lanes	55.24
Pavement Markings on Hills and Curves	54.98
Width of Travel Lanes	50.63
Length of Freeway Entry Lanes	48.73
Concrete Lane Guides for Turns	46.61
Size of Traffic Signal at Intersection	41.5

6.1.3 Perception-Reaction Time

In the ranking of highway safety issues of older drivers, perception reaction time was ranked third in importance. One of the most important applications of perception reaction time in highway design is in relation to stopping sight distance. It is essential to provide adequate stopping sight distance at every point along a roadway. As a minimum, sight distance should be long enough to ensure that a vehicle traveling at or near design speed can come to a complete stop prior to reaching a stationary object in its path. Stopping sight distance is the sum of two components - brake reaction distance (distance traveled from the instant of object detection to the instant the brakes are applied) and the braking distance (distance traveled from the instant the brakes are applied to when the vehicle is decelerated to a stop). The component of brake reaction distance is calculated using perception reaction time. The American Association of State Highway Officials (AASHTO) recommends a total perception reaction time of 2.5 seconds for all design speeds

Highway facilities designed on the basis of 2.5 seconds may pose safety implications to older drivers with longer perception reaction times. Several studies have investigated this situation and attempted to identify the existence of such a problem. A recent study used an in-vehicle instrumentation package to measure driver perception reaction times, braking distances and decelerations to unexpected and anticipated stops for different age groups (Fambro et.al, 1998). Four different types of studies were conducted. Study 1 was a pilot study, while studies 2, 3, and 4 were actual experiments from which the conclusions were drawn. Studies 2 and 3 where similar in regard to the use of a closed course, but study 2 employed a test vehicle whereas study 3 used the vehicles belonging to the test subjects. Study 4 was performed on open road conditions using personal vehicles. The observed Perception Brake Reaction Times (PBRT) for unexpected and expected object scenarios are presented in Tables 6.6 and 6.7 respectively.

Table 6.6: Summary of PBRT to an Unexpected Object

Study	Age Group	No. of Test Subjects	Mean PBRT (sec)	STD (sec)
Study 2	Older	12	0.82	0.159
	Younger	10	0.82	0.203
Study 3	Older	7	1.14	0.353
	Younger	3	0.93	0.191
Study 4	Older	5	1.06	0.222
	Younger	6	1.14	0.204

Table 6.7: Summary of PBRT to an Expected Object

Study	Age Group	Gender	No. of Test Subjects	Mean PBRT (sec)	STD (sec)
Study 2	Older	Female	7	0.66	0.216
		Male	7	0.65	0.228
	Younger	Female	6	0.57	0.167
		Male	6	0.48	0.088
Study 3	Older	Female	5	0.67	0.252
		Male	3	0.65	0.345
	Younger	Female	2	0.49	0.168
		Male	1	0.55	0.078

Additionally, a project conducted in 1996 studied intersection decision reaction time for older drivers (Naylor and Graham, 1996). Statistics on decision-reaction times observed in the field are listed in Table 6.8 for this study. The multivariate analysis of variance conducted on the data revealed that decision reaction times for the age groups were significantly different at a 95 percent confident level.

Table 6.8: Decision-Reaction Times for Different Age Groups

Statistic (sec)	Younger Group	Older Group	Total
Mean D-R time	1.16	1.32	1.24
Standard Deviation	0.45	0.54	0.50
Minimum D-R time	0.38	0.27	0.96
Maximum D-R time	2.48	3.00	3.00
85th Percentile	1.66	1.86	1.73

6.1.4 Gap Acceptance

Gap acceptance capabilities of older drivers at stop-controlled intersections was identified as the fourth issue in the order of highway safety importance. There is reason for concern since crash statistics indicate that poor gap acceptance at intersections is the leading causal factor for more than forty percent of all crashes at such locations. One particular study on the gap acceptance of elderly drivers on rural highways estimated critical gap values for elderly and other drivers (Yi, 1996). Observed critical gap values for elderly and other drivers were 7.31 and 5.19 seconds, respectively. This difference was found to be significant at the 90 % confidence level. The study further estimated that on average an elderly driver rejected 18 % of all usable gaps, compared to only 7.8 % for drivers in other age groups.

A study conducted by the University of South Florida (USF) looked into the gap acceptance capabilities of different age groups for different turning movements (Lu and Dai, 1997). Three age groups, Older, Middle, and Young along with the turning movements of left turning and through were considered in this study. A summary of the critical gaps observed is presented in Table 6.9. For both movements, gap acceptance behavior of older drivers and the other age groups was found to be significantly different at the 95 % confidence level. For the through movement it was found to be statistically significant for all three age groups.

Table 6.9: Observed Critical Gap Values for Different Age Groups and Turning Movements

Age Group	Critical Gap Value (seconds)	
	Left-turn Movement	Through Movement
Older Driver Group	6.95	6.13
Middle Driver Group	6.04	5.58
Young Driver Group	5.89	5.42
All Driver Groups	6.81	6.09

6.1.5 Deficiencies in Driving Knowledge

The fifth issue of safety concern as it relates to older drivers was the lack of driving knowledge. In 1992, McCoy et al. examined more than 2,000 driver license tests taken by older drivers who were renewing their Nebraska driving licenses. The study tried to identify whether there was a relationship between test scores and accident patterns. A score of 80 % was required to pass the test, but it most cases the average score of the older drivers was less than 80 %.

For three age groups, the average scores were as follows:

55 - 64 yrs: 79 %
65 - 74 yrs: 76 %
75 + yrs: 69 %

The results of this study clearly illustrate that older drivers were not versed in the various driving laws and regulations. In addition, the study attempted to correlate test scores with left-turning and right angle accident patterns. The percentage of questions answered correctly relating to these two types of accidents is given in Table 6.10. In each case, the percentage of correct answers decreased with increasing driver age. Drivers 75 years and older had the most difficulty answering the test questions.

Table 6.10: Driving Knowledge Test Scores Related to Right-Angle and Left-Turn Accidents

Questions	Age Group (years)		
	55-64	65-74	75+
Right-Angle Accident Related	83 %	78 %	72 %
Left-Turn Accident Related	86 %	82 %	73 %

6.2 School-aged Children

According to the findings of the two surveys and the feasibility for evaluation, five issues were selected for further examination. The five critical safety issues identified were high traffic volumes around school zones, speeding in and around school zones, illegal passing of school buses, lack of proper signage and traffic signals, and lack of drop-off and pick-up zones. In order to facilitate the development of appropriate countermeasures, it is essential to identify traffic and highway design characteristics that are prevalent in crashes involving motor vehicles and school-aged pedestrians and bicyclists. Furthermore, to perform an accurate safety analysis detailed information on the physical characteristics of roadways and environments surrounding the crash locations is needed. Consequently, it would be advantageous to utilize Geographic Information Systems (GIS) to facilitate the analysis and display of large quantities of data. There are various GIS software packages available in the market today. The most popular PC based software include ATLAS GIS, GIS PLUS, and MapInfo. In this study, MapInfo was the software of choice because of its multi-faceted functions.

6.2.1 Speeding In and Around School Zones

In order to evaluate this issue, hard-copy police reports of traffic crashes involving pedestrians and bicyclists were collected from the Metropolitan Planning Organization (MPO) of Brevard County, Florida. In addition, data were compiled for the 1990 Census of Population and Housing Summary Data File 3A, and student enrollment and location of each private and public school in Brevard County. Long-form crash reports involving pedestrians and bicyclists were obtained for a 5-year period (1993-1997). Pedestrians and bicyclists of the ages 5 to 15 were extracted from the crash reports and transcribed into electronic format file. A child's age could be easily determined from the birth date indicated in the reports. The 1990 U.S. Census of Population and Housing Summary Tape File 3A was used to examine the demographic and socioeconomic characteristics of Brevard County in an attempt to identify factors that may potentially impact traffic crashes involving school-aged pedestrians and bicyclists. This summary data file was geographically referenced and used in this study on a census block group level. Also, information pertaining to the spatial distribution of schools and student population for public and private schools was acquired from Brevard County Department of Education.

All three data sets collected were graphically depicted on the GIS coverage by geocoding. Geocoding is attached with a reference (known to the GIS coverage) to the traffic crash database. The GIS coverage is capable of interpreting latitude and longitude. If a traffic accident record, school, or census block has a x-y (latitude/longitude) coordinate, it will also have a position on the GIS coverage. As a result, all the information could be displayed on one map. Another advantage of using GIS for traffic crash analysis is the inherent ability of GIS to perform spatial analysis. Traffic crashes involving school-aged pedestrians and bicyclists in and around school zones can be analyzed in conjunction with demographic and socioeconomic characteristics as a means of identifying crash patterns.

The data analysis phase included analyzing traffic crash data for the statistical relationship between speed and traffic crashes involving school-aged pedestrians and bicyclists. A linear regression model was selected to describe the mathematical relationship between speed and severity of injury of school-aged pedestrians and bicyclists. The severity of an injury was provided in each crash report by the investigating officer. Crash severity varied on a scale of 1 to 6, with 1 indicating 'None Injury', 2-'Possible Injury', 3-'Non-capacitating', 4-'Incapacitating', 5-'Fatal with 90 days', and 6-'Non-Traffic Fatality'. In order to perform an accurate and comprehensive analysis of accidents involving solely school-aged pedestrians and bicyclists, five criteria were developed to select crash records in the crash database. The five criteria used to screen the data set were as follows: (1) under prevailing conditions a driver was driving at normal operating speeds instead of performing parking, backing, or turning maneuvers; (2) records that contained information on estimated vehicle speed at impact and posted speed limits; (3) records that contained information on injury severity level, (4) records that contained the location of a crash; and (5) the location indicated in the police report was in a school zone. After using the five criteria to screen the crash reports, a total of 41 crashes across Brevard County were analyzed (as shown in Figure 6.1).

The mathematical relationship between posted speed and crash injury severity is given below:

$$\text{Average Injury Severity} = 2.313 + 0.019 \times \text{Posted Speed}$$

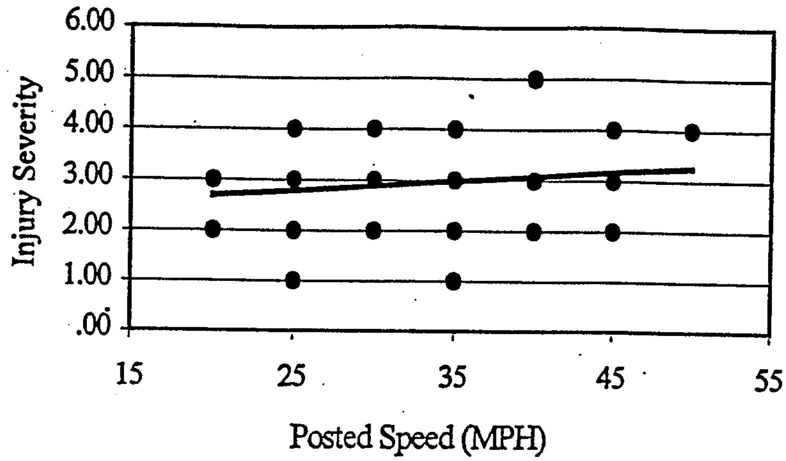

Figure 6.1: Statistical Relationship between Posted Speed and Injury Severity

The results of the statistical analysis of the model are given in Tables 6.11, 6.12, and 6.13. Table 6.11 provides goodness-of-fit statistics for the developed model. The very low R^2 values indicate a poor relationship between posted speed and injury severity. Table 6.12 presents the results of the ANOVA test and Table 6.13 shows the significance of the model coefficients.

Table 6.11: Model Summary (Posted Speed-Injury Severity Model)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.153	0.024	-0.002	0.9333

Table 6.12: ANOVA Results

Model	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance Level
Regression	0.798	1	0.798	0.916	0.344
Residual	33.102	38	0.871		
Total	33.900	39			

Table 6.13: Significance of the Model Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t Statistic	Significance Level
	B	Std. Error	Beta		
Constant	2.313	0.681	0.153	3.396	0.002
Difference	0.019	0.020		0.957	0.344

It can be inferred from the data that higher posted speeds result in more severe crashes involving school-aged children. However, it is worthwhile mentioning that the database of school-aged traffic crashes was very limited compared to other traffic safety databases. This may be due incomplete police reports and underreporting of crashes.

Several studies in the area of highway safety have indicated that demographic and alcohol related variables could be used in addition to vehicle speed to model the risk of traffic crashes. Unfortunately, these variables could not be quantified in this study. The research team tried to model the risk of traffic crashes with demographic variables such as universal population of school zone, school-aged children population, and student population of school zone; however, no significant statistical relationship could be established.

6.2.2 High Traffic Volume around School Zones

For the evaluation of this issue, traffic count data were collected from Metropolitan Planning Organization (MPO) of Brevard County, Florida. This computerized data file maintained by Brevard County MPO contains annual average daily traffic for individual segments of county, state and local roads for the time period of 1993 to 1997. Within the county's boundary, a total of 457 road segments with available traffic count data were assigned to a corresponding road segment and graphically displayed with the use of MapInfo. Accordingly, data for roadway segment traffic volume, traffic crashes involving school-aged pedestrians and bicyclists, school information, and socioeconomic-demographic characteristics were depicted on one map. However, traffic count data were only available for major roads, thereby limiting the number of roadways analyzed.

GIS technology played an integral role in further examining this issue. Twenty school zones in Brevard County were defined as study areas. A school zone was defined to be the area within one-mile radius of each school. If school zones were overlapping, efforts were then taken to combine zones together to form one school zone (as shown in Figure 6.2).

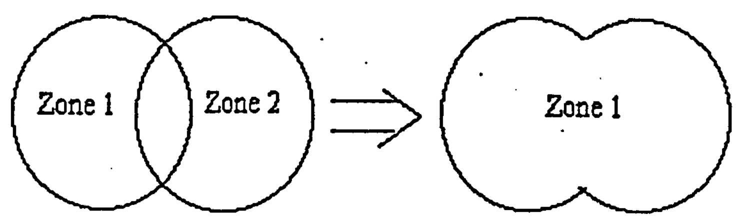

Figure 6.2: Definition of school zone

Several factors were taken into consideration prior to establishing the criteria for school zones. In the study Home-to-School Transportation Study (University of Florida, 1993), 2547 students living within a 2-mile radius of a school were surveyed to determine the effect of home-to-school distance on mode choice. As indicated in Figure 6.3, the home to school distance of 1-mile was the critical point where mode choice shifted from walk/bike to passenger cars. Secondly, Florida Statutes and Rules on School Transportation Section 236.083, F.S. states that the annual allocation for transportation of students to public school programs shall be determined (1) by reason of living 2 miles or more from school; and (2) by reason of being physically handicapped or enrolled in a teenage parent program, regardless of distance to school. Thus it can be assumed that if a student lives within two miles from a school and he or she does not have any physical disability; travel to and from school will be performed by walking, biking, or passenger cars. The third and most important factor is the unique characteristics of school areas, where the volume of school-aged pedestrians and bicyclists is considerably high. Taking into consideration these three factors, a 1-mile radius surrounding a school was chosen to represent the study area.

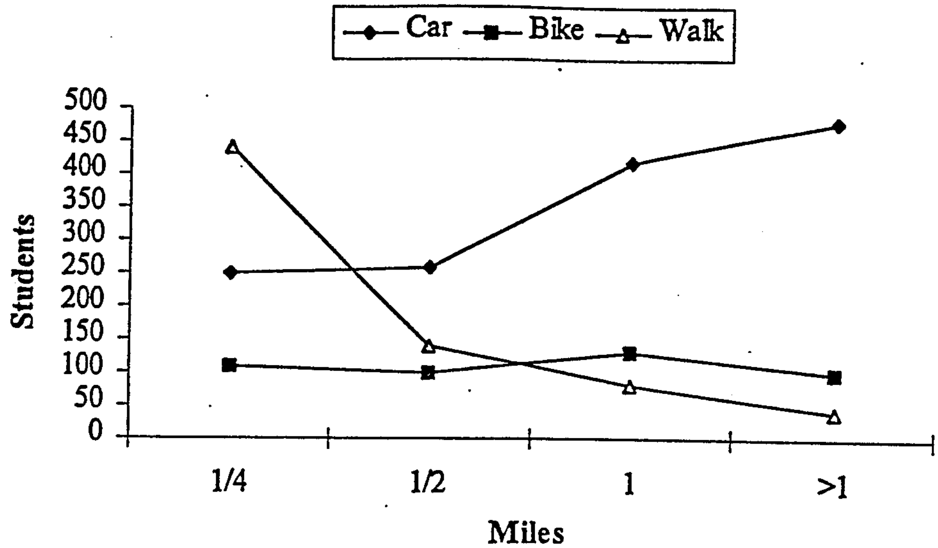

Figure 6.3: Effect of Distance on Model Split,

However, there were a limited number of road segments with available traffic counts that could be assigned to a school zone. In some school zones, only 3 or 4 road segments with traffic count data were available. In some cases, the defined school zone did not have traffic crash data. As a result, a total of 10 school zones were analyzed in this study. This limited data set affected the quality and reliability of the data analysis. In addition to the traffic count data, data of traffic crashes involving school-aged pedestrians and bicyclists, school information, and social and demographic characteristics were used in the traffic volume study. The traffic count data, along with the other data sets, were analyzed using MapInfo and SPSS to obtain a statistical relationship between the mean annual average daily traffic of a school zone and the risk of school-aged pedestrians or bicyclists.

Of all road segments with traffic counts, 55.4% were located inside 10 school zones. Although a total of 20 school zones were defined, 10 school zones were without traffic crash data or count data. Available and valid data are graphically illustrated in Figure 6.4.

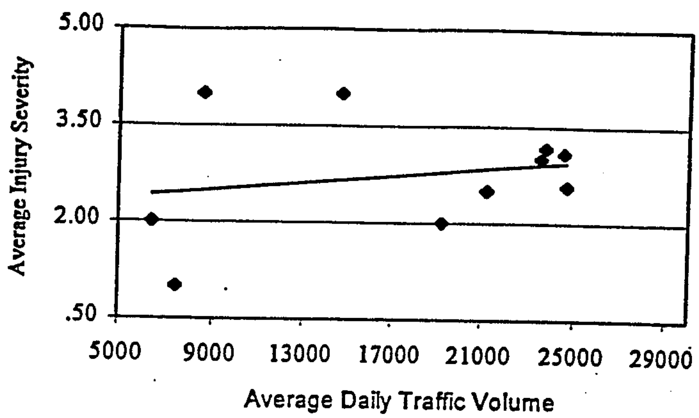

Figure 6.4: Statistical Relationship between Average Daily Traffic and Injury Severity

The mathematical relationship between average daily traffic and average injury severity involving school-aged pedestrians or bicyclists is:

$$\text{Average Injury Severity} = 2.243 + 2.814 \times 10^{-5} \times \text{Average Daily Traffic Volume}$$

The statistical analysis results are given in Table 6.14, Table 6.15, and Table 6.16. Goodness-of-fit statistics are provided in Table 6.14. Results of the ANOVA test and significance of model coefficients are illustrated in Tables 6.15 and 6.16, respectively.

Table 6.14: Model Summary (Volume- Injury Severity Model)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.227	0.052	-0.067	0.9591

Table 6.15: ANOVA Results

Model	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance Level
Regression	0.400	1	0.400	0.435	0.528
Residual	7.359	8	0.920		
Total	7.759	9			

Table 6.16: Significance of the Model Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t Statistic	Significance Level
	B	Std. Error	Beta		
Constant	2.243	0.802	0.227	2.798	0.023
Difference	2.814*E-5	0.000		0.660	0.528

From the goodness-fit-statistics, it can be seen that there is a poor statistical relationship between the average traffic volume and the injury severity. This occurrence may be due in part to the quality of the data sets. In order to establish a stronger relationship between average traffic volume and injury severity, it is suggested that law enforcement and governmental agencies collect more traffic crash data of school-aged pedestrians/bicyclists. Likewise, a traffic crash database containing accurate and complete information should be developed and maintained for school-aged pedestrian and bicyclists.

6.2.3 Illegal Passing of School Buses

In this section, a literature review was undertaken to obtain information regarding illegal passing of school buses. The literature review was primarily based on two studies conducted by the Texas Transportation Institute (TTI) at Texas A&M University (1984), and the Center for Urban Transportation Research (CUTR) at University of South Florida (1996). Although there is a ten-year interval between the two studies, the research methodologies and study findings were nonetheless similar to one another. At loading and unloading zones, there is a major concern for the safety of children boarding and exiting the school bus. This concern stems from the high frequency of school buses being illegally passed. The main purpose of these two studies were to: (1) determine the number, location, and circumstances of illegal passes occurring on school bus routes; (2) obtain a greater knowledge and understanding of driver characteristics on the roadway network; and (3) identify and recommend areas for further research. The research methodologies and findings of the two studies are discussed in the following section.

In these two studies, a school bus driver or an observer aboard a school bus was asked to record each individual illegal passing. In the Texas study, researchers recorded illegal passing by direction, type of roadway, type of passing, and time of day (morning and afternoon) for a three-day period. Observers also noted the manner in which vehicle passed stopped school buses (e.g., stopped then passed, slowed then passed, or passed without slowing). In the Florida study, illegal passing data were recorded for two typical schools in 58 school districts. In addition to collecting similar information as the Texas study, the Florida study improved the method of investigation by compiling more detailed and useful information. The following information was recorded in the Florida Study.

- time of occurrence (recorded in both Florida and Texas studies),
- number of students at the school bus stop,
- whether the vehicle passed traveling in the same or opposite direction as the school bus (recorded in both Florida and Texas studies),
- whether the vehicle passed on the left or right of the school bus,
- type of vehicle that passed-by,
- type of roadway (recorded both in Florida and Texas studies),
- whether the pass-by occurred in an urban or rural locale,
- whether the pass-by occurred on a paved or unpaved roadway surface, and
- whether the strobe light was in use at the time of the pass-by.

As recorded in the Florida Study, 10,590 vehicles illegally passed a total of 3,427 school buses. The total number of illegal passes (10,590) represented data from 58 of 67 school districts in Florida. Analysis of the data showed that approximately 89 percent of all school buses illegally passed during the field study were Type C buses, as displayed in Table 6.17. Of the buses identified as Type C, approximately 10 percent were equipped with wheel chair lifts. This finding might suggest that motorists illegally passed these particular buses more frequently due to the extra time it took for a student requiring a wheel chair to board or exit a school bus.

As indicated by the illegal passing data, no explicit trend existed between the time of day and frequency of illegal passes. A close examination of data showed that illegal passing was almost evenly distributed between the morning hours of 6:00 AM to 10:00 AM (48.3 percent) and the afternoon hours of 2:01 PM to 6:30 PM (49 percent). The midday period from 10:01 AM to 2:00 PM accounted for only 2.7 percent of the total recorded illegal passes, as indicated in Table 6.18.

Table 6.17: Illegal Passes by School Bus Type and Presence of Wheel Chair Lift (CUTR, 1996).

Type of School Bus	Percent without wheel chair lift	Percent with wheel chair lift	Total
A	0.3%	0.0%	0.3%
B	1.8%	1.0%	2.8%
C	79.5%	9.8%	89.3%
D	7.2%	0.4%	7.6%
Total	88.8%	11.2%	100%

Table 6.18: Time of Illegal Passing (CUTR, 1996).

Time	Frequency	Percent
6:00 AM to 10:00 AM	4,727	48.3%
10:01 AM to 2:00 PM	273	2.7%
2:01 PM to 6:30 PM	4,796	49%
Valid Observations	9,796	100%
Missing Observations	794	N/A

Table 6.19 implies that the majority of illegal passing occurred on two-lane roadways; nearly 56 percent of all recorded illegal passing occurred on this type of roadway. Furthermore, 23.5 percent of all illegal passes occurred on four-lane roadways with two-way left-turn lanes. This was an important finding since only a small percent of bus stops in Florida are located on this type of roadway. Four-lane and more than four-lane roadways with medians accounted for 15.1 and 5.6 percent of all illegal passing, respectively.

Table 6.19:Type of Roadway (CUTR, 1996).

Type of Roadway	Frequency	Percent
2 lanes	5,836	55.8%
4 lanes, no median	2,456	23.5%
4 lanes, with median	1,583	15.1%
More than 4 lanes with median	590	5.6%
Valid observations	10,465	100%
Missing observations	125	N/A

The majority of illegal passing occurred when the vehicle in violation was travelling in the direction opposite the stopped school bus, accounting for 65.7 percent of all illegal passes. Vehicles traveling in the same direction as the stopped school bus accounted for the remaining 34.3 percent of the illegal passes. Table 6.20 shows the results related to the direction of the illegal passing.

Table 6.20: Vehicle Passed from the Same or Opposing Direction (CUTR, 1996).

Direction of illegal passing	Frequency	Percent
Opposing	6,691	65.7%
Same	3,487	34.3%
Valid observation	10,178	100%
Missing observation	412	N/A

Surprisingly, nearly four-percent of all recorded illegal passes occurred on the loading and unloading side (right side) of stopped school buses. While the remaining 96 percent occurred on the left side, as depicted in Table 6.21. A cross tabulation of the data indicated that approximately 78 percent of right-side illegal passes occurred on two-lane roadways as opposed to 13 percent on four-lane roadways with two-way left-turn lanes. While the remaining 10 percent of illegal passes occurred on four or more lane roadways with median separation.

According to school bus drivers, passenger cars are most often flagged for violation of school bus stopping law. Table 6.22 shows that passenger cars accounted for 75.4 percent of the 10,590-recorded illegal passes. While light and heavy trucks accounted for 20.5 and 3.8 percent of all illegal passes, respectively. Interestingly enough, two police cars, one fire truck, and one school bus were observed passing a stopped school bus during the field study.

Table 6.21 Vehicle Passed in the Left or Right of the School Bus (CUTR, 1996)

Side	Frequency	Percent
Left	9,887	96.0%
Right	415	4.0%
Valid observation	10,302	100%
Missing observation	288	N/A

Table 6.22: Type of Vehicle that Illegally Passed (CUTR, 1996).

Type of Vehicle	Frequency	Percent
Car	7,900	75.4%
Light truck	2,149	20.5%
Heavy truck	401	3.8%
Van	18	0.2%
Motorcycle	3	<0.03%
Police car	2	<0.02%
Fire truck	1	<0.01%
School bus	1	<0.01%
Valid observations	10,475	100%
Missing observations	115	N/A

Additionally, approximately 68 percent of all illegal passes occurred at school bus stops. Most frequently, the range of 1 to 5 students were observed boarding or exiting the stopped school bus at the time of illegal passing, as shown in Table 6.23. Of the 3,427 stopped school buses illegally passed during the field study, 78.4 percent (2,687) had a roof-mounted white strobe light activated at the time of illegal passing as shown in Table 6.23.

Table 6.23: Number of Students at School Bus Stop (CUTR, 1996).

Number of Students	Frequency	Percent
1 to 5	7,128	67.9%
6 to 10	1,705	16.3%
11 or more	1,662	15.8%
Valid observations	10,495	100%
Missing observations	95	N/A

Table 6.24: Strobe Light in Use at Time of Illegal Passing (CUTR, 1996).

Strobe in Use	Frequency	Percent
Yes	7,428	78.4%
No	2,045	21.6%
Valid observations	9,473	100%
Missing observations	1,117	N/A

In the Texas Transportation Institute study, a driver's lack of understanding of Texas traffic regulation law was identified to be the leading cause for the illegal passing of stopped school buses. The survey results are as follows:

1. There is no requirement for vehicles to stop for yellow warning lights or hazard lights, yet nearly half (48%) of the drivers surveyed said that they would stop for a yellow warning light and an additional 31 percent for hazard lights. These misinterpretations are errors of

caution (i.e., stopping when it is unnecessary) indicating that a significant portion of the driving public does not fully understand the meaning of various signal configurations.

2. There is no requirement for traffic in opposing lanes of a divided highway to stop for a school bus displaying red loading lights; nevertheless 95 percent of the drivers surveyed stated that they would stop. Once again this is an error of caution, clearly showing that the majority of drivers are not aware of state law on stopping for school buses on multi-lane facilities.
3. With only red loading lights, 6.2 percent of the drivers indicated that they would proceed without stopping. This type of misunderstanding is termed as an error of recklessness (i.e., not stopping when necessary). Surprisingly, when the red loading and hazard lights are used simultaneously the error percentage actually increased to over 10 percent. This confirms that many drivers are confused with the meanings of various signal configurations.

6.2.4 Lack of Proper Signage and Traffic Signals

This section provides a general overview to the problem of lack of proper traffic signage and signals. Traffic signs and signals are important to the safety of school-aged pedestrians and bicyclists because they aid in the safe interaction of young pedestrians/bicyclists and motorists. Many factors contribute to the effectiveness of traffic control devices (TCDs), including understandability, recognition time, conspicuity, legibility distance, and learnability. The Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) sets forth several basic requirements for TCDs (Federal Highway Administration, 1997). Motorists' understanding is an important element in the overall effectiveness of TCDs, since they will serve little purpose if they are misunderstood.

A review was conducted on several studies relating to pedestrian/bicyclist traffic control devices. These studies provide an overview of the problems associated with pedestrian/bicyclist related traffic control devices by examining: (1) driver understanding of alternative pedestrian/bicyclist related traffic signage and signals; (2) pedestrian and bicyclist understanding of alternative traffic signage and signals; and, (3) effectiveness of alternative pedestrian or bicyclist signs and signal messages.

In 1995, Tidwell and Doyle conducted a nationwide survey to identify frequently misinterpreted traffic control devices. In this study, researchers evaluated a respondent's knowledge of pedestrian/bicyclist traffic control devices. Respondents were asked for their interpretation of 'WALK' and 'DON'T WALK' pedestrian traffic signals. Also requested were the interpreted meanings of crossing and advance crossing signs. The survey questionnaires were distributed at driver's license examination centers in 48 states across the U.S.

Also in 1995, Picha et al. conducted a similar survey to identify frequently misinterpreted traffic signs and signals, and to further develop alternate device designs. The three-phase study included an evaluation of issues on the basis of a focus group, initial survey, and a follow-up survey.

In addition to these studies on existing pedestrian/bicyclist traffic control devices, research was conducted to determine possible improvements in these signs and signals. Dutt, Hummer, and Clark (1995) conducted a survey to evaluate the use of strong yellow green pedestrian crossing signs (the color of strong yellow green is an unassigned color listed in MUTCD). The surveys were performed at four locations with strong yellow green warning signs at mid-block pedestrian crossings.

Of primary concern is the effectiveness of pedestrian/bicyclist related traffic control devices. In a study aimed at measuring the effectiveness of traffic control devices, data were collected on pedestrian/bicyclist behavior, traffic and pedestrian volumes, pedestrian-vehicle conflicts, and site characteristics (Zegeer, Cynecki, and Opiela, 1984). Video-recording and manual collection techniques were used to obtain the data.

A summary statistical analysis must be performed to analyze the data from the returned questionnaires. In Tidwell and Doyle's study (1995), the chi-squared test was used to analyze survey responses. This statistical test was chosen because of the categorical, non-normal nature of the survey questions. The statistic was used to determine if significant differences existed between groups. In the study of "Evaluation of Innovative Pedestrian Signalization Alternatives" (Zegeer, Cynecki, and Opiela, 1984), the z-test for proportions was used to determine whether the proportion of occurrences in one group was significantly different from that of a second group.

6.2.4.1 Pedestrian/Bicyclist Related Traffic Signals

The answers of many respondents were wrong when asked about the meaning of flashing 'DON'T WALK', 'WALK', and flashing 'WALK' messages (Tidwell, and Doyle, 1995, and Zegeer, 1984). Pedestrians and bicyclists are often given a false sense of security by the presence of a steady 'WALK' message. Pedestrians do not realize that conflicts with turning vehicles may still occur for a 'WALK' message. The 1978 MUTCD allowed the use of a flashing WALK message to warn pedestrians of turning vehicles. However, this practice was eliminated in the 1988 MUTCD because it was determined to be unclear.

In 1984, Zeeger conducted a study to evaluate alternate pedestrian signals. The findings are as follows:

1. The steady 'DON'T START' clearance indication (a three-lens pedestrian signal) resulted in a significant improvement over the flashing 'DON'T WALK' display in terms of pedestrian violations and associated clearance-related conflicts at the test sites.
2. The steady 'DON'T WALK' display for the clearance interval provides no improvement over the flashing 'DON'T WALK' signal.
3. The 'WALK WITH CARE' display was tested in conjunction with a 'WALK' indication to warn pedestrians of turning vehicles. The 'WALK WITH CARE' message was found to be effective in reducing turn-related conflicts as well as pedestrian violations. Further analysis showed that these displays were effective for moderate to high right-turn volumes.

6.2.4.2 Pedestrian/Bicyclist Related Traffic Signs

- *End School Zone Sign* – In Tidwell and Doyle's study (1995), many participants realized that they could resume normal vehicular speed after travelling through a school zone. All of the participants indicated a strong preference for the use of the current 'End School Zone' sign (S5-2) either alone or in combination with a speed limit (R2-1) sign.
- *School Advance Sign* – Also in Tidwell and Doyle, for the standard sign (S1-1), survey results indicated that 32 percent of the participants associated this sign with a school area and 46 percent associated it with an advance warning of a school crosswalk. When the school plaque was added below the standard sign, the association of the "School Crosswalk" increased significantly.
- *Yield Sign* – In Zegeer's study (1984), a yield sign stating 'YIELD TO PEDESTRIANS WHEN TURNING' was found to be effective in reducing turning conflicts, particularly right-turn conflicts. The sign would be most appropriate on the right side of intersection approaches, particularly where right-turning motorists fail to yield right-of-way to pedestrians.
- *Warning Sign* – Also in Zegeer's study, the pedestrian warning sign stating 'PEDESTRIANS WATCH FOR TURNING VEHICLES' was found to be effective in reducing right-turn conflicts. This sign would be appropriate in place of or in conjunction with the 'YIELD TO PEDESTRIANS WHEN TRUNING' sign discussed previously. The 'PEDESTRIANS WATCH FOR TURNING VEHICLES' sign could be applicable to sites with frequent incidents of right-turn pedestrian accidents.

6.2.5 Lack of Drop-off and Pick-up Zones

School site design is critical to ensure a safe environment for bicyclists, pedestrians, and motorists. On the school site, parent drop-off and pick-up points are areas where there are numerous vehicular movements and conflicts. In cases where busses are provided the problem is more acute. Although the issue of lack of drop-off and pick-up zones was identified as an important issue, there have been few studies conducted to address this concern. However, there are several guidelines for the design of new and improvement of existing school sites. In addition, each state has its own statutes governing the safety of children in and around school zones. It is recommended that site design begins with an evaluation of the location of the facility to intersections and arterials, commercial and residential centers, while considering the potential for safe ingress and egress by bicyclists, pedestrians, and motorists (University of Florida, 1993).

Safe pedestrian and bicycle access to a school site must be evaluated in light of volume, characteristics, and classification of traffic. At parent drop off points, it is recommended that continuous sidewalks be constructed so children do not have to disembark on roadways or parking lots. In school site design, there are two key safety principles that should be strictly followed:

(1) Adequate physical space should be provided for all modes of transportation to the degree that each is found on the school or planned for in the future, and
(2) The physical routes provided for the basic school modes of transportation should be separated as much as possible from each other (Arizona Department of Transportation, 1983). Also, student-loading zones should be completely separated from bus zones.

Increasing popularity of neighborhood based schools and pedestrian/bicycle friendly paths decrease the demand for buses. Bus loading zones should be physically separated from biking and walking routes, as well as parent pick-up and drop-off areas.

6.2.6 Summary

In summary, vehicle speed has an impact on the safety of school-aged pedestrians and bicyclists. As posted speed of a roadway increases, so does the average injury severity of crashes. The results of the data analysis show that high traffic volume in and around school zones significantly impact the safety of school-aged pedestrians/bicyclists. Due to a limited number of school zone traffic counts, the statistical relationship was found to be insignificant. During the loading and unloading of students, illegal passing of stopped school buses (with stop arms extended and red lights flashing) can jeopardize the safety of school-aged children. In evaluating the issue of lack of traffic signage, it was shown that pedestrians and bicyclists were often given a false sense of security by the presence of a steady 'WALK' message. As for the issue of lack of pick-up and drop-off zones, there are few studies addressing the safety aspects of this topic. However, several agencies have published guidelines for the design of parent/school bus pick-up and drop-off zones.

6.3 Young Drivers

6.3.1 General Lack of Driving Experience

Most officials claim that inexperience and immaturity are the leading causes for crash involvement of young drivers, rather than alcohol consumption and teenage risk taking. While young drivers learn basic skills to operate a vehicle, they are often unprepared for difficult situations encountered during rush hour, inclement weather, and traffic emergencies. Nighttime driving is especially a problem for young drivers; five times as many crashes occur during night hours than during the day.

According to Brown (1986), drivers undergo a three-step maturing process. The first stage, "car craft", young drivers learn maneuvering, braking, steering, shifting gears, changing lanes, and choosing proper lanes. In the second stage, perceptual skills are developed which include proper visual scanning, knowledge of driving limitations due to weather and road conditions, ability to recognize hazardous situations, and anticipation of other drivers' actions. The final stage drivers develop decision-making skills. These skills, Brown argues, are the most complex and take the longest time to develop. They involve judgement, reasoning, logic, and deciding when or how not to drive. As compared to older drivers, mistakes in perception and decision-making are the common cause of crashes involving 16-19 year-old drivers

6.3.2 Lack of driver training programs

An important factor contributing to the teen driver problem is the shrinking number of driver education programs in high schools. In 1975, 84% of all high schools in the U.S. offered driver education. By 1984, that number had decreased to 68%, and as of 1995, only 52% of high schools in the U.S. had such programs. According to the Tampa Tribune, (10/01/97) only 9% of students in Florida eligible for driver education are actually enrolled.

Even when driver education is available, the material discussed may not be entirely useful to today's young drivers. The curriculum in most programs has not changed much over the last 50 years. (Saunders, 1998) Very little effort has been made to determine which topics are most appropriate for modern driver education programs. Another problem is that many of the current driver education teachers are not properly trained to instruct drivers. In many cases, the teacher's area of expertise is in a completely unrelated subject. Some instructors may not have had any training for driver skill instruction, while others only teach it part time.

Often, money is the major factor that governs the existence of high school driver education programs. When education budgets are cut, funds for driver education programs are usually among the first to get the ax. Allen Robinson, CEO of the American Driver and Traffic Safety Education Association, questions why parents are so willing to pay for music and sports lessons, yet reluctant to cover the costs of formal driver training. Robinson points out that a lifetime of safe driving can save an individual $50,000, according to economists' estimates, but schools, governments, and parents are unwilling to spend $300 per student for driver education. (Robinson, 1998)

6.3.3 Lack of Seat Belt Use

Traffic crashes impose a tremendous cost to society in terms of bodily injury, loss productivity, and most importantly loss of life. Each year, it is estimated that over 3 million motorists are injured, 41,000 killed, and 150 billion dollars lost as a result of traffic crashes. Seat belts are a car occupant's easiest and most effective way of preventing injury and premature death. If a seat belt is worn, front seat passengers are 45% less likely to suffer fatal injuries in traffic crashes. Approximately 9,500 lives are saved each year from use of a seat belt. Their risk of moderate-to-critical injury is cut in half when seat belts are worn.

Drivers fall into one of three categories according to the degree of seat belt usage. *Full-time users* are more likely to be female, and claim that their primary reason for buckling up is to avoid injury. While *part-time users* believe that seat belts lessen injury severity, they usually don't use them on short, familiar, low-speed trips. Often they claim to be full-time users, since they do wear a seat belt when they feel they are at greater risk. *Non-users* constitute 5-10% of drivers. This group typically resents government regulation of their behavior, and believes that in a crash, seat belts would cause more injury than they could prevent. Non-users are unlikely to feel responsible for social and economic consequences of their (non-) action, and are more likely to drink and drive. The typical non-user is an unmarried male under the age of 30 with little college education.

Traffic injuries are the leading cause of death among people age 6 to 27. Teens are especially vulnerable to injury and death in crashes because they use seat belts less than other drivers. Young people buckle their seat belts only 35% of the time, compared to an overall usage rate of 68%. Infrequent use of seat belts by teens is commonly attributed to peer pressure, feelings of invulnerability, greater risk-taking and thrill seeking, and other emotional stresses. Another possible explanation for low seat belt use among young people is that they often drive older vehicles. These cars make seat belts harder to use because of less sophisticated restraint systems.

6.4 International Tourists

In the consideration of highway safety importance, international tourists received the fourth highest ranking. The number of studies conducted in regard to this driving population subset is very limited. Available literature in terms of critical issues/concerns of international tourists is discussed in this section.

6.4.1 Difficulty in Recognizing and Understanding Traffic Signs

In addressing the highway safety of international tourists, the most critical issue identified was the difficulty of tourists to recognize and understand traffic signs. The most important and probably the only study conducted and published in this area is "Evaluation of International Signing Practices" conducted by Wilbur Smith Associates for the Florida Department of Transportation (FDOT, 1994). In this study, problems faced by international tourists were identified by directly contacting them at the international airports of Orlando and Miami. It was found that most international travelers' problems were related to guide signs, rather than regulatory or warning signs. Under two headings, Freeway or Interstate signs and State Route or Surface Arterial signs, the problems mentioned most frequently by international visitors are listed in Table 6.25. The problems are listed in the order of frequency of response.

Table 6.25: Reported Problem Areas in Relation with Signs

Category	Problems
Limited Access Routes - Exit Signs	1. Advance warning of upcoming exits 2. Destination or route signing on exit signs 3. Destination signing to airports 4. Destination signing to car rental agencies
Limited Access Routes - General Signs	1. Route signing to other interstates or routes 2. Consistency of the use of either a route name or a number for the same route 3. Use of cardinal directions on guide signs 4. Route confirmation signs
State Route Signs	1. Trailblazing or destination signing on other routes or interstates 2. Destination signing to airports 3. Consistency of the use of either a route name or number for the same route 4. Use of cardinal directions on guide signs 5. Route confirmation signs 6. Destination signs to car rental agencies 7. Use of symbols in signage 8. Use of diagrammatic type signs

It was also discovered that each of the problems cited by international visitors was caused by one or more of the following six reasons:

1. The proper information was not available on the sign.
2. The sign message was visually inadequate.
3. The information on the sign was inadequate.
4. The information on the sign was misleading.
5. The information on the sign was confusing.
6. The proper sign to convey the information was non-existent.

The six underlying factors mentioned above were divided into sub categories and the problem locations analyzed.

In another study, Hawkins et al. (1996) dealt with Mexican driver understanding of traffic control devices in Texas. For the purpose of this study, Mexican drivers were identified to be residents of Mexico driving either automobiles or commercial trucks in the border areas of Texas. Even though this target population can not be classified as international tourists, they do have similar characteristics. The assessment of driver comprehension of traffic control devices in the study by Hawkins has provided a clear picture of the current issue. The results of the survey conducted to determine the level of comprehension of regulatory, warning, and other signs are given in Table 6.26.

Table 6.26: Survey Results for the Understanding of Traffic Control Devices

(a) Regulatory Signs

Device	Sample Size	Response Rate (Percent)				
		Correct	Partially correct	Incorrect	Not sure	Unknown
Stop sign	601	98.7	0.0	0.5	0.2	0.7
Yield sign	603	63.9	0.0	21.5	13.6	1.0
Day/Night speed limit sign	601	82.3	15.2	1.3	0.5	0.7
Do not enter sign	582	90.7	0.0	4.6	3.4	1.2
One way sign	560	83.3	0.0	13.8	1.6	1.3
Stop for school bus sign	557	57.9	24.2	14.6	3.3	0.0
Fasten seat belts –state law	587	33.2	23.2	5.5	36.6	1.5

(b) Other Signs

Device	Sample Size	Response Rate (Percent)				
		Correct	Partially correct	Incorrect	Not sure	Unknown
Road work ahead sign	579	80.3	1.0	2.9	14.9	0.9
Right lane ends sign	502	8.4	11.2	16.9	62.3	1.2

(c) Warning Signs

Device	Sample Size	Response Rate (Percent)				
		Correct	Partially correct	Incorrect	Not sure	Unknown
Curve sign with speed plate	528	65.4	30.8	2.5	1.0	0.4
Two-way traffic sign	538	93.3	0.6	4.1	1.9	0.2
Advance railroad warning	602	39.1	40.5	6.5	12.8	1.2
School crossing sign	545	52.3	34.3	11.6	1.5	0.4

6.4.2 Lack of Information about Driving Laws and Customs in US

The second most important issue when considering the highway safety of international tourists is the lack of information concerning driving laws and customs. In the aforementioned study by Wilbur Smith Associates, lack of information was cited as the second most frequently mentioned factor among non-signing related issues. A video shown on flights prior to arriving in the U.S. was identified by the study as an important method of addressing this problem. This video developed by Dollar-Rent-a-Car discussed Florida driving and safety issues.

6.4.3 Other Issues

As far as international tourists were concerned, the issues of unfamiliarity with the roadway system, confusion in translating English units into metric, and unfamiliarity with the driving system received third, fourth, and fifth rankings, respectively. However, these issues were not addressed in detail in any of the past studies. It is also not possible to provide a completely familiar roadway and driving system for visitors coming from vastly different countries. A coordinated effort is therefore required to educate and familiarize international visitors about the roadways, driving systems, laws, customs and conditions in Florida.

6.5 People with Disabilities

The full participation of people with disabilities is important to society by lessening the economic burden (societal costs) that would otherwise be used to take care of them. Full participation is also essential to their independent living and overall well being. However, the mobility needs of the disabled requires access to the transportation system be in a manner that is both safe and barrier-free.

Several issues that are important to the highway safety of people with disabilities are addressed in the following:

- Are intersections appropriately designed so that people in wheelchairs can cross streets in time?
- Is street crossing facilities adequate for people with blindness?
- How is safety ensured for people in wheelchairs to get around highway work zones?
- Are there standard methods of recalling licenses from people with progressive disabilities?
- How safety of adapted vehicles for drivers with disabilities is ensured?

The issue of private vehicle access for people with disabilities is further addressed in this study. This issue is related to not only highway safety of people with disabilities but also for the traveling public in general. Four aspects of the issue are subsequently discussed.

6.5.1 Persons with Driving Disabilities

In accessing the market potential for vehicle adaptive equipment, TRB (1993) estimated the number of persons whose disability either prevented driving or caused driving problems. Table 6.27 shows theses estimates in various degrees of driver disability. Over 60 percent of all people with driving disabilities drive without the need for special equipment. An additional 23 percent represent consumers who currently drive, but for whom adaptive equipment is either necessary or beneficial. The other 15 percent represent people for whom driving requires major vehicle modifications and adaptive equipment. These estimates do not include persons who do not drive and those who would not be able to drive even with the use of special equipment. Nor do these estimates include those who do not drive because of age, preferences, or other factors preventing them from driving. A more complete picture of the total driving population and its sub-groups is given in Figure 6.5.

Table 6.27: Persons with Disabilities by Degree, 1987 US.

Degree of Driving Disability	Estimated Number of Persons	Percent Total
Drive Now without Special Equipment But Would Benefit from Enhanced Design	12,000,000	63
Drive Now without special equipment but would benefit from.such equipment	3,820,000	20
Drive now with special equipment	525,000	3
Health or disability prevents driving but special equipment and design would enable to drive	2,815,000	15
Total	19,160,000	100

Source: TRB (1993).

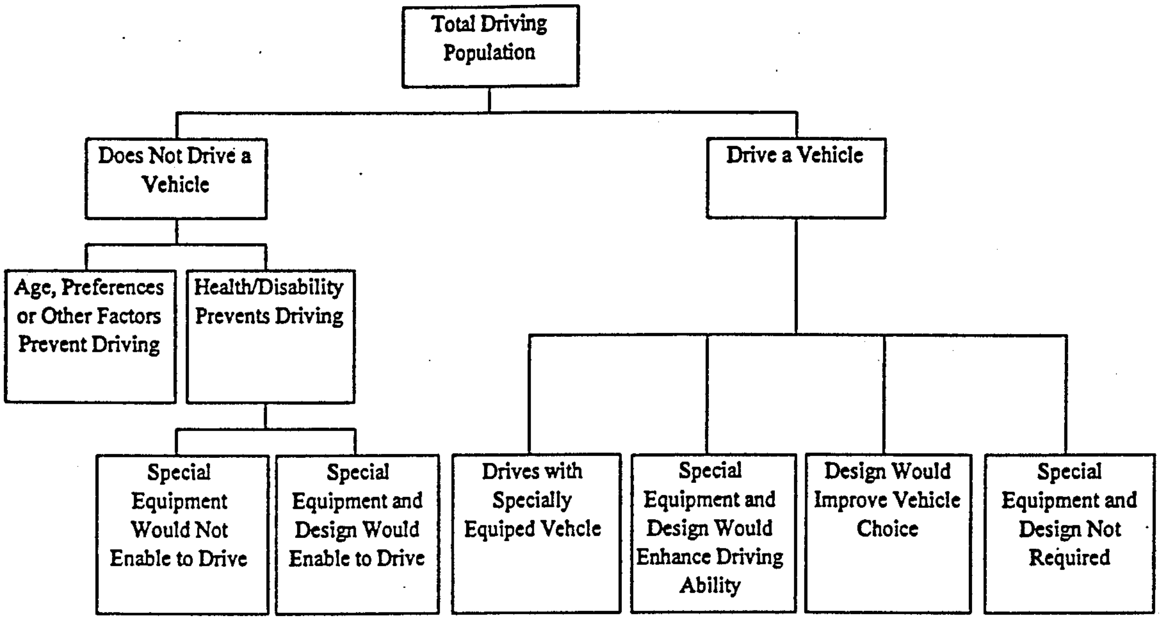

Figure 6.5: Driving Population and Sub-Groups.

6.5.2 Vehicles Adapted

NHTSA's National Center for Statistics and Analysis (NCSA) recently compared data from three different sources to estimate the number of vehicles adapted for use by persons with disabilities. These three sources are NHTSA's National Automotive Sampling System Crashworthiness Data System (NASS/CDS), the National Center for Health Statistics (NCHS), and the Census Bureau. The estimates are summarized in Table 6.28 along with the 95 percent confidence interval for each estimate.

Table 6.28: Estimates of the Number of Vehicles with Adaptive Equipment by Data Source

Data Source	Estimated Number of Adapted Vehicles	95 Percent Confidence Interval
Census 1992 Truck Use Survey	184,000	158,000 - 264,000
NCHS 1990	211,000	117,000 - 251,000
NASS/CDS	382,907	100,765 - 665,049

Source: NHTSA (1997a)

NCHS estimates that approximately 211,000 persons with disabilities used some type of adaptive equipment with their motor vehicles. This estimate is based on a 1990 survey of the American public on a number of national health issues. The 1992 Truck Use Survey of the Bureau of Census obtained data from a sample of respondents on the use of adaptive equipment in trucks. Based on this sample, NHTSA estimates that approximately 184,000 trucks operate with some type of vehicle adaptation. Every year, NASS/CDS collects extensive information using in-depth investigations of a sample of approximately 6,000 crashes, involving light vehicles (passenger cars, light trucks, and vans) towed due to damage caused by the crash. Based on NASS/CDS for the period of 1995-1996, NHTSA estimates that 382,907 registered vehicles were fitted with some type of adaptive equipment. The NCHS and Census estimates of the number of vehicles with adaptive equipment fall within the range of the 95 percent confidence limits of the NASS/CDS estimate. As a result of the Americans with Disabilities Act, NHTSA expects that the number of vehicles with adaptive equipment will continue to increase, as a larger proportion of the population begins to age and as access to employment, travel, and recreation continues to improve for persons with disabilities

6.5.3 Wheelchair Users Injuries and Deaths

NCSA recently estimated the number of injuries and deaths of wheelchair users involved in motor vehicle crashes during the period 1991-1995 (Table 6.29). The estimation is based on the National Electronic Injury Surveillance System (NEISS) of the Consumer Product Safety Commission. NEISS collects data on a nationally representative sample of persons treated in hospital emergency rooms each year for injuries related to consumer products. NEISS is a 3-level system consisting of monitoring of persons treated for injuries in hospital emergency rooms, follow-up telephone interviews with injured persons or witnesses, and comprehensive investigations with injured persons and/or witnesses. NEISS obtains data from a sample of 91 of the 6,127 hospitals nationwide with at least six beds that provide emergency care on a continuing 24-hour basis. NCSA used the NEISS data on injuries to wheelchair users to develop national estimates of the number of injuries and deaths to wheelchair users associated with situations involving motor vehicles.

Table 6.29: Wheelchair Users Injured or Killed from All Causes, 1991-1995.

Type	Estimated Number of Persons	Percent Total
Involving Motor Vehicles	7,121	2
Others	292,613	98
Total	299,734	100

Source: NHTSA (1997b)

During the five-year period (1991-1995), a total of 299,734 persons in wheelchairs were estimated to be injured. More than 2 percent (7,121) of these persons were injured or killed in incidents involving motor vehicles.

Table 6.30 shows the estimated number of wheelchair users injured or killed by the type of vehicle involved. Vans were involved in almost half of the injuries to wheelchair users during the five-year period. Passenger cars were involved in another 30 percent, with the remainder involving buses, ambulances, and trucks.

Table 6.30: Wheelchair Users Injured or Killed by Type of Vehicle, 1991-1995.

Type of Vehicle	Estimated Number of. Persons	Percent Total
Van	3,410	48
Passenger Car	2,153	30
Bus	856	12
Ambulance	506	7
Truck	196	3
Total	7,121	100

Source: NHTSA (1997b)

Table 6.31 shows the number of wheelchair users injured or killed by the type of activity. The five categories include improper or no securement of the wheel chair (in the motor vehicle); collision between a wheelchair and a motor vehicle; wheelchair lift malfunction; transferring to or from a motor vehicle; and falling onto or off of a ramp. Improper or no securement was involved in more than one-third of the cases. Another quarter was the result of a collision between a wheelchair and a motor vehicle.

Table 6.31: Wheelchair Users Injured or Killed by Type of Activity, 1991-1995.

Type of Activity	Estimated Number of Persons	Percent Total
Improper or No Securement	2,494	35
Collision with Motor Vehicle	1,819	26
Lift Malfunction	1,366	19
Transferring to or from Motor Vehicle	1,035	15
Falling On/Off Ramp	407	6
Total	7,121	100

Source: NHTSA (1997b)

Table 6.32 shows the number of wheelchair users injured or killed by the type of activity and type of vehicle. None of the wheelchair users injured in situations of improper or no securement were associated with passenger cars. Of the 2,494 wheelchair users whose injuries were related to improper securement, 65 percent involved vans, while 18 percent involved ambulances and 17 percent involved buses. Meanwhile, 83 percent of the wheelchair users whose injuries were related to a collision with a motor vehicle involved passenger cars. Trucks were involved in 8 percent, while vans and buses were involved in 7 and 2 percent, respectively.

Table 6.33 shows the estimated number of wheelchair users injured by injury severity. The estimated number of wheelchair users killed is 43, representing 0.6 percent of the wheelchair users. All of these estimated fatalities were associated with collisions involving a motor vehicle.

Table 6.32: Wheelchair Users Injured or Killed by Type of Vehicles and Selected Activity Type

Type of Vehicle	Selected Activity Type			
	Improper or No Securement		Collision with a Motor Vehicle	
	Estimated Number of Persons	Percent	Estimated Number of Persons	Percent
Van	1,616	65	122	7
Passenger Car	0	0	1,511	83
Bus	422	17	34	2
Ambulance	455	18	0	0
Truck	1	0	152	8
Total	2,494	100	1,819	100

Source: NHTSA (1997b)

Table 6.33: Wheelchair Users Injured or Killed by Severity and Medical Disposition

Severity	Estimated Number of Persons	Percent Total
Death	43	0.6
Injury	7,078	99.4
Total	7,121	100

Source: NHTSA (1997b).

6.5.4 Type of Vehicles Adapted and Adaptations

Through NHTSA's web site, users (drivers and passengers) of vehicles with adaptive equipment are invited to complete a brief survey on the type of vehicle modified for use and the equipment and/or modifications in use. Results for the period from May 1997 to March 1998 are available. A total of 59 visitors to the NHTSA web site completed the survey. Of these visitors, 36 were drivers of the adapted vehicle. Ten of the visitors were passengers in the adapted vehicle, while 13 used the vehicle as both passenger and driver. Table 6.34 shows the type of vehicle modified for use by persons with disabilities. An equal number of respondents, 20 out of the 59 respondents, indicated that the adapted vehicle being used was either a passenger car or standard van. Another 17 respondents indicated that the modified vehicle was a minivan. None of the respondents indicated that the modified vehicle was a heavy truck (over 10,000 pounds) or a motor home.

Table 6.34: Type of Vehicle Adapted for Use by Persons with Disabilities

Vehicle Type	Number of Respondents	Percent Total
Passenger Car	20	34
Standard Van	20	34
Minivan	17	29
Sports Utility	1	2
Pickup Truck	1	2
Heavy Truck	0	0
Total	59	100

Source: NHTSA (1998).

Table 6.35 shows the equipment and modifications in use in their vehicles. The responses ranged from modifications for accommodating wheelchair users to vehicle control adaptations. A list of 25 specific vehicle modifications or adaptations is shown in the survey. Respondents could select as many choices from the list as were applicable. Only the five most often reported types of modification are included in the table.

Table 6.35: Top Five Modifications/Adaptations in Use by Persons with Disabilities.

Type of Modification	Percent Respondents Use
Hand Control	56
Wheelchair Securement	42
Lift	34
Automatic Door Opener	31
Steering Control Device	29

Source: NHTSA (1998).

6.6 New Immigrants

Immigrants are coming to this country in record numbers. Many of these people come from environments that vastly differ from that of this country. In addition to traditional factors related to highway safety (i.e., alcohol use, weather conditions, driver age, driver gender) a set of unique issues exist for new immigrants. These include unfamiliarity with the transportation system, language barriers, cultural differences, and inadequate driver education.

6.6.1 Background

Upon contact with a new culture, individuals may undergo a change in any or all of six areas of psychological function: language use, cognitive style, personality, identity, attitudes, and stress (Marin and Marin, 1991). This process of learning and adaptation can include an initial stage of crisis or conflict that is often followed by the acceptance of an adaptation strategy. In terms of attitudes, an individual can adapt by assimilation, integration, or rejection of the attitudes prevalent in the new culture and environment. In terms of language, an individual may completely shift to English, become bilingual, or maintain their native language. The process of adaptation has been shown to affect new immigrants' mental health status, levels of social support, levels of social deviance, alcoholism, and drug use; political and social attitudes; and health behaviors such as the consumption of cigarettes and the use of preventive cancer screening practices.

The process of adaptation may also affect the ease and rapidity with which new immigrants become accustomed to the U.S. highway system. This ease and rapidity of integration by new immigrants may in turn affect their safety of highway travel as drivers, passengers, or pedestrians (NHTSA, 1995).

6.6.2 The Issues

New immigrants are unfamiliar with the transportation system because of vast differences in transportation practices of the U.S. as compared to that of their home countries. In some instances, walking or bicycling may have been their primary mode of transportation in their country. As pedestrians or bicyclists, they may not be accustomed to high-speed traffic. They may be forced to learn to drive in the typically low-density environment. This task of learning to drive can be more difficult for them than for natives, since immigrants face language barriers and cultural differences. Often, new immigrants do not have the opportunity to observe the manner in which people drive safely. To make things worse, many of new immigrants are taught by fellow peers, who themselves are new drivers. Furthermore, many immigrants are either teenagers or elderly. These barriers, differences, and difficulties further add to the already high risks experienced by teenagers and elderly.

6.6.3 Evidence

Several of these issues emerged in a recent study of highway safety needs of Hispanic communities in the United States (NHTSA, 1995). High concentrations of Hispanic population were selected from California, Colorado, Florida, New Jersey, New York, and Texas and the District of Columbia. The study involved telephone and onsite discussions with representatives from highway safety, law enforcement, emergency medical services, health, education, and general service agencies and organizations in the study areas. In addition, the study conducted nearly 50 focus groups of community members from the study areas. Among others, the study identified segments of the Hispanic communities with special highway safety problems. One of these segments included new immigrants.

New immigrants were second to young males in the frequency with which study participants mentioned vehicular and pedestrian safety problems. Often these two segments of the population were mentioned together. Some agency and organization representatives stated that new immigrants could actually be the segment of the community with the greatest need, since they are not accustomed to new driving conditions, language, customs, and laws. New immigrants were most frequently mentioned in areas that experienced or is expected to experience a large number of new arrivals, particularly Texas and California.

Representatives of highway safety organizations reported that one of the major problems for new immigrants who come from rural areas is the disorientation they may feel as they try to become familiar with life in a large city. The sheer volume of traffic, signs, and roadway configurations are unfamiliar and confusing even to those who have substantial driving experience.

Participants attributed unsafe driving behavior of new immigrants to habits brought from their countries of origin. A participant in Florida indicated that unsafe driving behavior is due to the view that driving is more of a social event than a means of transportation.

Language barriers and cultural differences create problems in a number of aspects related to highway safety. These include outreach efforts by highway safety organizations, law enforcement activities, emergency medical services, and efforts by educational institutions.

CHAPTER 7: COUNTERMEASURES AND MATRICES

This chapter presents countermeasures for issues and concerns identified earlier. These countermeasures are intended to address the problems that were identified for each special population group. Identification of these countermeasures was based on the results of a literature review and the current practices related to the methods of improving safety. The suitable countermeasures are summarized and presented in the form of tables or matrices for clarification.

7.1 Older Drivers

This section discusses countermeasures to the safety problems of older drivers. Driver education is one of the countermeasures suggested here and in many other studies conducted earlier. This is based on the evaluation of the driving knowledge of older drivers. The evaluation has indicated that they have deficiencies primarily in right of way rules, procedures for crossing and making left turns at intersections, safe following distances and lane positioning in freeways, driving in congestion, backing out and parking procedures, etc. Therefore, driver education is necessary to address the identified critical issues directly or indirectly. Previous researchers have ruled out the necessity for developing new driver education programs in the presence of three nationally prominent driver education programs (McCoy et al. 1992). They are (1) Coaching the Mature Driver (National Safety Council), (2). 55 Alive/Mature Driving (American Association of Retired Persons), and (3) Safe Driving for Mature Drivers (American Automobile Association). All the three programs have been recognized as those addressing the driving deficiencies of older drivers adequately.

Another countermeasure that has been identified is physical and perceptual therapy. They can be used to improve the performance of older drivers. The study by McCoy et al., mentioned earlier, employed physical therapy. This involved exercises designed to improve trunk rotation, shoulder flexibility and posture. It was observed that overall improvements in physical fitness and flexibility would lead to improving reaction time, cognitive performance, and energy levels. With regard to the perceptual therapy, they employed visual perception exercises designed to improve spatial orientation, visual discrimination, figure ground perception, visual closure and visual memory. These exercises provided significant improvements to the older drivers.

Another countermeasure towards improving safety of older drivers is employing licensing and screening measures, so that those drivers who experience certain incapabilities are kept away from these activities. Actions such as age-based renewal procedures would increase not only the safety of older drivers but also that of the overall driving population. However, careful consideration and further studies are necessary because the countermeasure reduces the mobility of older drivers. This leads to issues of individual rights versus benefits to society.

In the light of advancements in Intelligent Transportation Systems (ITS), vehicular improvements can be employed as another countermeasure capable of addressing several critical safety issues and concerns identified for older drivers. Vehicles equipped with sophisticated instruments that would make "hands-off" navigation possible will be the ultimate solution for special population groups like older drivers. The role of safety devices like seat belts and air bags are considerable too. Among the other driving options available, to make driving easier is automatic transmission, power steering, press button controls for windows, adjustable steering wheel and seats.

The countermeasures mentioned earlier like driver education programs, therapies, and vehicular improvements are effective only for those people who can afford the service. Unlike those mentioned above, engineering countermeasures are applicable to all road users making them more effective. Several engineering countermeasures suggested addressing the critical issues and concerns identified for older drivers are improving roadway, signage, signal timing and pavement marking are. The roadway improvements suggested primarily involve intersection design improvements since the older drivers experience greater difficulties in processing information and making quick decisions at intersections. Intersection design improvements, that could be considered in reducing the older driver crashes at these locations, include providing left-turn lanes, increasing sight distances, simplifying intersection configurations, providing proper roadway lighting and re-evaluating pedestrian walking speeds to provide sufficient timings. In addition to roadway design improvements mentioned earlier, signage improvements on highways are suggested for further consideration. Highway signs are vital in passing information to the driver. Most of the information drivers receive from the highways' information system is received from the signs. They provide route guidance, warning, regulatory, and advisory information. Improving highway sign visibility is one of the major parameters that strongly impact the driving performance of older drivers. Visibility of highway signs can be improved in several ways: (1) increase letter size, (2) improve conspicuity of signs, (3) multiple signage, and (4) use of symbols on signs.

Improvements in pavement markings can be implemented to achieve better safety for older drivers. All drivers use markings and delineation to help track or follow the road. Some forms of marking and delineation are reflectorized, thus helping drivers track the road both during day and night. Thus, the emphasis should be on the installation and maintenance of good pavement marking and delineation system. The system would include the need for solid edge lines, longer dashes, a shorter stripe-to-gap cycle, painted and reflectorized guardrails, and delineator posts. Emphasis should be on the maintenance procedure where they must be regularly inspected to ensure that they meet minimum standards and specifications. This is particularly true for degree of brightness and contrast.

Signal timing improvements may be necessary, in particular, changes to the yellow interval to address the slower perception reaction times exhibited by older drivers as a result of their decreased mental and physical capabilities. Re-evaluating the perception reaction times of older drivers at intersections is necessary and the currently accepted values of perception brake reaction time in computing stopping sight distances (2.5 seconds) needs to be checked for sufficiency.

Reducing speeds by road design and traffic control, in areas that require complex maneuvers, may also improve the safety situation of older drivers. Complex situations in dense or high-speed traffic can be eliminated wherever possible as a countermeasure. Such measures can be accomplished by application of one way systems, prohibiting dangerous lanes, by avoiding or eliminating level junctions and by separating flows.

All the countermeasures mentioned earlier and their capability to address each of the issues and concerns identified are critical for older drivers. They are summarized in Table 7.1, in the form of a matrix.

7.2 School-Aged Children

In this section, the countermeasures for the issues that were addressed previously are presented, based on extensive review of publications related to school-aged children and transportation safety. Authorities from transportation engineering, safety, enforcement, education, and other organizations throughout the nation prepared these publications. Although each individual issue has its specific countermeasures, it is strongly recommended that when facing any of the complex issues of highway safety of school-aged children, a systematic analysis of the problem be performed, and all the possible countermeasures be considered. These procedures may include identification of all possible deficiencies of a child's route with a clear understanding of the prevailing transportation characteristics, selection of route improvements and control measures, implementation of route improvements and periodic evaluation of routes. Definite procedures and a step-by-step process needs to be established to help the various local agencies and groups to work together. These local agencies and groups involve police (Enforcement), traffic engineers (Engineering), school administration (Education), and parents.

Table 7.1: The Countermeasure Matrix for the Safety Issues of Older Drivers

Countermeasure / Issue/Concern	Driver Education	Physical and Perceptual Therapies	Licensing and Screening Measures	Vehicular Improve-ments	Roadway Imrove-ments	Speed Related Measures	Signal Timing Improve-ments	Signing Improve-ments	Pavement Marking Improve-ments
Night Time Visibility			X		X				X
Driving in Congestion		X		X	X				
Freeway Driving		X	X	X					
Maneuvering Curves		X		X	X				
Deficiencies in Driving Knowledge	X			X				X	X
Location and Size of traffic Signs and Lettering	X		X	X	X	X		X	X
Perception Reaction Time		X	X	X	X	X	X	X	X
Gap Acceptance		X		X		X	X		
Narrow lanes		X			X		X		

7.2.1 Speeding in and around School Zones

The countermeasures for the issue of speeding in and around school zones can be discussed under three main categories. They are engineering, education and enforcement.

7.2.1.1 Engineering Countermeasures

Intersection Improvement – Intersections, in particular signalized intersections, are the most dangerous part of the road network for pedestrians. Most pedestrian fatalities in Florida occur at intersections. There are 32 possible vehicle-pedestrian conflicts at a 4-legged intersection (Florida Department of Transportation, 1992). It is recommended in the Florida Pedestrian Plan (Florida Department of Transportation, 1992) that intersection areas (conflict zone) be kept to a minimum to reduce the exposure of a pedestrian/bicyclist to vehicles, reduce pedestrian crossing distances and increase sight distances. These practices make the vehicle path clearer and reduce the relative speed between opposing movements. Also, channelization with medians, and right turn slip lanes with channelization islands can reduce the conflict zone and provide safe refuge for pedestrians. Furthermore, prohibited turns that are dangerous to pedestrians can be blocked. As for residential neighborhood streets, roundabouts can be an effective treatment for reducing pedestrian/vehicle conflicts and vehicle speeds (Florida Department of Transportation, 1992). In crossing the roundabout, pedestrians only need to cope with one direction of vehicle movement.

Traffic Calming – Traffic calming aims to reduce the dominance and speed of motor vehicles. It employs a variety of techniques to cut vehicle speeds. Measures include physical alterations to the horizontal and vertical alignment of the road and changes in priority (Cyclists' Touring Club, 1991). Special facilities for bicycle traffic are rarely seen in areas subject to traffic restraint or low speed limits. This offers a measure of one of the many inherent benefits traffic calming holds for cyclists. They can move around in relative safety when riding in slower traffic. These measures may be more appropriate in older and narrower streets, which have less scope for satisfactory cycle paths or other special cycling facilities. A wide range of people are benefited by traffic calming –residents, pedestrians and cyclists– thus obviating the need to wrestle with financial justifications for cycle facilities, such as segregated provision and special engineering treatment at junctions.

The following general design guidelines should be followed in the implementation of traffic calming schemes (Cyclists' Touring Club, 1991):

(1) Where possible, provide cyclists with an alternative that by-passes physical obstacles such as chicanes or ramps,
(2) Where a reduction in carriage-way width is employed as a speed control measure, careful consideration should be given to how motorists and cyclists can safely share the remaining space,
(3) Surface materials, particularly on ramps, should have a good skid resistance, while textured surfaces should not be so rough that they endanger the stability of cyclists or cause severe grazing if the cyclist should come off,
(4) A smooth transition on entry and exit to ramps should be provided. Inclines should be clearly indicated,
(5) If the traffic-calming feature is to be installed on a road with an overall gradient, it must be noted that cyclists are likely to approach it at different speeds uphill and downhill. This should be taken into consideration while designing the feature.

In addition, three general observations could be made from successful traffic calming schemes (Cyclists' Touring Club, 1991):

(1) Where consistent low speeds (less than 20 mph) are required, such as in residential areas, physical traffic calming features should be positioned sufficiently close to each other to deter unnecessary acceleration and braking,
(2) The use of appropriate signage is important to remind drivers that they are entering a traffic restraint area. Public awareness campaigns facilitate the acceptance of lower speed,
(3) Sympathetic speed limits are used to reinforce the physical speed control measures.

Possible Policy Change – Medians are effective measures to reduce exposure of the pedestrian to traffic while crossing a roadway. Refuge islands and medians help to eliminate pedestrian/bicycle-vehicle traffic conflicts by providing a "refuge" or safe retreat from oncoming traffic.

Medians are recommended in the Florida Pedestrian Plan (Florida Department of Transportation, 1992), wherever the crossing distance exceeds 60 feet, to provide a refuge for slow or late crossing pedestrians. Pushbuttons should be installed in the median. Also, handicap ramps or a full cut should be provided through the median. Preferably, the refuge islands should be a minimum of 6 feet in width and in no case less than 4 feet wide to reduce potential danger to the island users.

Possible Design Change – Many signalized intersections are pedestrian unfriendly because of the speed and complexity of vehicle movements and the number of lanes added for capacity of the roadway. As recommended in the Florida Pedestrian Plan (Florida Department of Transportation, 1992) one-way pair streets, slip lanes and medians may be used to reduce the number of lanes that need to be crossed. Also, consideration should be given to roundabouts at intersections in residential neighborhoods as they effectively reduce vehicle speed and pedestrian/bicyclist-vehicle conflicts.

7.2.1.2 Education Countermeasures

Children's Education – Research of nationwide school-aged pedestrian/bicyclist crash data reveals that the most significant factor is the irresponsible and unpredictable behavior of the pedestrian or bicyclist. Typical examples of unsafe behavior of school-aged pedestrians and bicyclists include playing in the roadway, not crossing at intersections, and walking or biking at night without proper reflective clothing. Hence, the education for school-aged pedestrians and bicyclists, about proper attire, traffic regulations, and safety issues, is vital. Information campaigns on safety are substantially inadequate in teaching children life-long skills in assessing gap acceptance, route planning, and other vital traffic skills. Regular, repetitive and a cumulative education program that offers a minimum of ten lessons per year between kindergarten and grade 2 is essential to develop minimal traffic competency. As indicated in the Florida Pedestrian Plan (Florida Department of Transportation, 1992), the traffic safety education program should be supported in these ways: (1) implementation of traffic safety education program for 5-9 year olds in school, (2) conducting mass media campaigns, through family and child-orientated companies such as AAA, food, drug, fast food, and toy stores, to promote safe walking skills, and (3) training of crossing guards, bus drivers, and school liaison officers to reinforce the classroom pedestrian/bicyclist safety lessons. This could be done by county Sheriff's and Police Chiefs' Associations. AAA also has material for adult crossing guard training.

Other Roadway Users' Education – The general public need to be educated about the severity and the nature of pedestrian safety problems. Pedestrian safety education should be included in driver education classes. It is essential to gain public backing and support. Such campaigns should include secondary school and college students. They should target areas with high incidence of school-aged pedestrian/bicyclist problems. The campaign could use various mass media such as television, newspapers, pamphlets, video, and other materials.

7.2.1.3 Enforcement Countermeasures

Enforcement of pedestrian and bicyclist safety issues will be an important factor in bolstering pedestrian systems. Strict monitoring of the actions of the pedestrian and the automobile driver reinforce the view that pedestrians are a vital part of the transportation system. Enforcement of the basic safety strategies would make society more aware of other modes of travel. Warnings should be issued to those who do not follow these safety precautions. Enforcement methods would help the population realize that the transportation system should be equally accessible and safe for all users. The population should also understand that all transportation modes are required to follow the laws of the state.

Pedestrians – Pedestrians need to follow the rules of the road and should be given warnings if they disregard them. A widely unknown practice is that pedestrians should travel against traffic and should not travel in the same direction as traffic along a roadway. Florida Statute 316.130 (4) states "Where pedestrian facilities are not provided, any pedestrian walking along and upon a highway shall, when practicable, walk only on the shoulder on the left side of the roadway in relation to the pedestrian's direction of travel, facing traffic which may approach from the opposite direction".

Enforcement Officers – It is recommended in the Florida Pedestrian Plan (Florida Department of Transportation, 1992) that officers receive more training in completing crash report forms and gathering evidence concerning pedestrian-vehicle crash reconstruction. The evidence includes speed of the vehicle, location of impact, and weather conditions. It is also recommended that law enforcement officers involve themselves in community programming.

Summary of the countermeasures to speeding in and around school zones is given in Table 7.2.

7.2.2 High Traffic Volume around School Zones

7.2.2.1 Engineering Countermeasures

Higher motor vehicle traffic volumes represent greater risk for bicyclists. More frequent passing situations are less comfortable for school-aged pedestrians and bicyclists unless special design treatments are provided. In a study conducted by the Federal Highway Administration (1994), the traffic operations and design recommendations (as shown in Table 7.3, Table 7.4, and Table 7.5) are given based on three ranges of Average Annual Daily Traffic (AADT)- under 2,000 AADT; 2,000 to 10,000 AADT; and over 10,000 AADT.

Table 7.2: Countermeasures for Speeding in and around School Zones.

7.2 (a) By Category

Engineering Countermeasures	
Roadway section	1. Build traffic calming area around schools to reduce vehicle dominance and speed. 2. Build refuge islands and medians on roads with high traffic volume and speeds to reduce exposure of the pedestrian when crossing a roadway.
Signalized intersection	1. Build one-way pair streets. 2. Build medians to reduce number of lanes to be crossed.
Residential neighborhood	1. Build roundabouts at intersections in residential neighborhoods to reduce pedestrian-vehicle conflicts and vehicle speed.
Education Countermeasure	
Children	1. Implement traffic safety education program for 5-9 year olds. 2. Conduct mass media campaign. 3. Implement training programs for crossing guards, bus drivers, and school officers.
Drivers	1. Pedestrian and bicyclist safety education should be taught in drivers' education classes. 2. Conduct mass media campaign.
Enforcement Countermeasure	
Pedestrians	1. Give warnings or citations to pedestrians or bicyclists if they do not follow the road rules.
Enforcement Officers	1. Give enforcement officers more training in completing traffic crash reports and in gathering evidence concerning pedestrian and bicyclist crash reconstruction.

7.2 (b) By Type of Countermeasure

Engineering Countermeasures	1. Provide highway signage in school bus loading and unloading zones 2. Improve visibility of bus stop signal arm 3. Provide lettering on rear of school bus.
Education Countermeasures	1. Develop and distribute materials related to the school bus stop law. 2. Analyze the basic school bus driver curriculum and make necessary changes.
Enforcement Countermeasures	1. Promote awareness and focus efforts in the direction of school bus stop law enforcement within the state law enforcement community.

Table 7.3: Traffic Operations and Design Recommendations for New Adult and Teenage Bicyclists on Urban Section without Parking.

Average motor vehicle operating speed	Average annual daily traffic (AADT) volume											
	Less than 2,000				2,000–10,000				Over 10,000			
	Adequate sight distance		Inadequate sight distance		Adequate sight distance		Inadequate sight distance		Adequate sight distance		Inadequate sight distance	
Less than 30 mph	wc 14	truck, bus, RV		wc 14	wc 14	Truck, bus, RV		wc 14	bl 5	truck, bus, RV		bl 5
		wc 14	wc 14			wc 14	wc 14			bl 5	bl 5	
30 – 40 mph	bl 5	bl 5	bl 5	bl 5	bl 5	bl 6	bl 6	bl 5	bl 5	bl 6	bl 6	bl 5
41 – 50 mph	bl 5	bl 5	bl 5	bl 5	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6
Over 50 mph	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6

Key: wc=wide curb lane**, sh=shoulder, sl=shared lane, bl=bike lane**, na=not applicable

****WC** numbers represent "usable width" of outer lanes, measured from lane stripe to edge of gutter pan, rather than to face of curb. If no gutter pan is provided, add a minimum of 1-ft for shy distance from face to curb.

BL numbers indicate minimum width from the curb face. The bike lane stripe should lie at least 4 ft from the edge of the gutter pan, unless the gutter pan is built with adequate width to serve as a bike lane by itself.

Table 7.4: Traffic Operations and Design Recommendations for New Adult and Teenage Bicyclists on Urban Section, With Parking.

Average motor vehicle operating speed	Average annual daily traffic (AADT) volume											
	Less than 2,000				2,000 – 10,000				Over 10,000			
	Adequate sight distance		Inadequate sight distance		Adequate sight distance		Inadequate sight distance		Adequate sight distance		Inadequate sight distance	
Less than 30 mph	wc 14	truck, bus, RV		wc 14	wc 14	truck, bus, RV		wc 14	bl 5	truck, bus, RV		bl 5
		wc 14	wc 14			wc 14	wc 14			bl 5	bl 5	
30 – 40 mph	bl 5	bl 5	bl 5	bl 5	bl 5	bl 6	bl 6	bl 5	bl 6	bl 6	bl 6	bl 6
41 – 50 mph	bl 5	bl 5	bl 5	bl 5	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6	bl 6
Over 50 mph	na	na	na	na	na	na	na	na	na	na	na	na

Key: wc=wide curb lane**, sh=shoulder, sl=shared lane, bl=bike lane, na=not applicable

**WC numbers represent "usable width" of outer lanes, measured from the left edge of the parking space (a minimum of 8 to 10 ft from the curb face) to the left stripe of the travel lane.

Table 7.5: Traffic Operations and Design Recommendations for New Adult and Teenage Bicyclists on Rural Section

Average motor vehicle operating speed	Average annual daily traffic (AADT) volume											
	Less than 2,000				2,000 – 10,000				Over 10,000			
	Adequate sight distance		Inadequate sight distance		Adequate sight distance		Inadequate sight distance		Adequate sight distance		Inadequate sight distance	
Less than 30 mph	sh 4	truck, bus, RV		sh 4	sh 4	truck, bus, RV		sh 4	sh 4	truck, bus, RV		sh 4
		sh 4	sh 4			sh 4	sh 4			sh 4	sh 4	
30 – 40 mph	sh 4	sh 4	sh 4	sh 4	sh 4	sh 6	sh 6	sh 4	sh 6	sh 6	sh 6	sh 6
41 – 50 mph	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6	sh 6
Over 50 mph	sh 6	sh 6	sh 6	sh 6	sh 8	sh 8	sh 8	sh 8	sh 8	sh 8	sh 8	sh 8

Key: wc=wide curb lane, sh=shoulder, sl=shared lane, bl=bike lane, na=not applicable

Four basic facilities are used to accommodate bicyclists. These facilities are: (1) shared lane: shared motor vehicle/bicycle use of a "standard" width travel lane, (2) wide outside lane: an outside travel lane with a minimum width of 14 ft, (3) bike lane–a portion of the roadway designated by striping, signage, and/or pavement markings for preferential or exclusive use for bicycles, and (4) shoulder–a facility physically separated from the roadway and intended for bicycle use. It is also recommended that at school crossings with high traffic volumes, students be provided with home-school route map (Institute of Transportation Engineers, 1984). The map should include location of crosswalks, crossing guards, traffic signals, sidewalks, and bike paths.

7.2.3 Illegal Passing of School Buses

In the study entitled "Illegal Passing of Stopped School Buses in Florida" performed by the University of South Florida (CUTR, 1996), countermeasures were recommended and organized into actions at both the state and local levels. At the state level, the Florida Commissioner of Education, the Florida Legislature, and other relevant groups representing law enforcement, planning, and local school districts should work together to develop and implement practical and effective countermeasures to this problem. Their responsibilities include:

(1) Promotion of awareness and focussing of efforts in the direction of school bus stop law enforcement within the state law enforcement community,

(2) The development of high impact public service announcements in television, radio, and newspapers to educate private motorists about the school bus stop law and graphically remind them of the potential consequences of violating the law;

(3) The development and distribution of additional material related to school bus stop law. Information pertaining to traffic stopping for a stopped school bus should be included in automobile license tag renewal notices, rental car contract signoffs, and on billboards;

(4) Clarification of the section in the Florida Driver's Handbook that pertains to the school bus stop law;

(5) Providing highway signage in school bus loading and unloading zones, advising motorists of the law pertaining to stopping for stopped school buses, and to inform motorists of areas where school buses make frequent stops;

(6) Conducting research on possible changes to the School Bus Specifications by the State Board of Education or pilot testing to include higher visibility of school bus stop signal arms, lettering on the rear of school buses advising motorists of school bus stop law, or other safety measures that may be proposed such as video cameras mounted on school buses to record the vehicles that illegally pass;

(7) The Department of Education analyzing the Basic School Bus Driver Curriculum and making necessary changes to standardize the school bus stop warning procedure; and

(8) The Department of Education identifying best practices and making recommendations for school districts regarding the establishment of safe school bus routes and stops.

In addition to the above-recommended countermeasures, it is suggested in the Florida study that the existing law pertaining to illegal passing of stopped school buses be amended to better reflect the current driving environment. The summary of the possible countermeasures is shown in Table 7.6.

Table 7.6: Countermeasures of Illegal Passing of School Bus

Engineering Countermeasures	• Provide highway signage in school bus loading and unloading zones. • Improve the visibility of stop signal arm, put lettering on rear of school bus.
Education Countermeasures	• Develop and distribute materials related to the school bus stop law. • Analyze the basic school bus driver curriculum and make necessary changes.
Enforcement Countermeasures	• Promote awareness and focussing of efforts in the direction of school bus stop law enforcement within the state law enforcement community.

7.2.5 Lack of Proper Traffic Signage and Traffic Signals

Traffic Control Signs–The fundamental purpose of traffic control signs is to convey a message to the motorist or pedestrian. Many studies have suggested that traffic signs may not be fully effective in achieving the desired change in vehicle operations without steady enforcement activities. The traffic engineering countermeasures for the issue of lack of proper traffic signs suggested by many studies are as follows:

(1) The current distinctive feature between crossing signs and advance crossing signs should be evaluated, probably using heavier lines or different colors. The use of supplemental distance plates may also prove useful (Tidwell, and Doyle, 1995);

(2) The use of informational signs indicating the meaning of the WALK and flashing DON'T WALK symbols at intersections should be considered (Tidwell and Doyle, 1995). Education campaigns can also be used to make the public more aware of the meaning of the WALK and DON'T WALK signs (Florida Department of Transportation, 1992);

(3) The use of strong yellow-green (SYG) pedestrian crossing signs. The strong yellow-green is one of the unassigned colors listed in the Manual of Uniform Traffic Control Devices. It is found that the SYG signs are more conspicuous, induce greater alertness in road users, and have a strong association with caution (Dutt, Hummer, and Clark, 1995);

(4) A School Advance Sign may be used ahead of an established school crossing or school facility adjacent to a highway. This sign must be used in conjunction with a School Crossing sign (Institute of Transportation Engineers, 1984);

(5) A School Crossing Sign is intended for use at established school crossings and may not be necessary at a crossing where there is a yield or stop sign or a traffic signal (Institute of Transportation Engineers, 1984);

(6) School Speed Limit Signs as specified in the MUTCD are necessary wherever a reduced speed limit is imposed for the safety of school pedestrians. The number and length of these zones should be minimized and the reduced limit must be in effect only during periods of school pedestrian activity (Institute of Transportation Engineers, 1984);

(7) Flashing Beacons, activated during periods when a sign is applicable, may be used to improve the effectiveness of one or more of the above mentioned signs by drawing motorists' attention to these devices (Institute of Transportation Engineers, 1984); and,

(8) Parking Signs are intended to inform motorists of parking regulations that have been established to alleviate hazards that would exist if parking were permitted. Stopping and parking of vehicles should be prohibited at locations where it will limit visibility of pedestrians using crosswalks. It should also be prohibited if school grounds are very near to the curb or roadway edge such that careless activities of the children may come in conflict with passing traffic (Institute of Transportation Engineers, 1984).

For lack of proper signage, the law enforcement countermeasures are as follows (Tidwell, and Doyle, 1995):

(1) Drivers who do not yield to the right-of-way of pedestrians at the appropriate time should be given a citation; and

(2) Pedestrians who exhibit unsafe behavior should be given a citation, particularly in corridors that have traditional pedestrian safety problems;

Traffic Control Signals–In the long term, traffic signals are more cost effective compared to crossing guards. These signals may be coordinated to provide efficient traffic flow. In some cases, installation of a school-crossing signal may not eliminate the need for a crossing guard (Institute of Transportation Engineers, 1984).

As suggested by many studies, the following traffic engineering countermeasures are provided for lack of effective traffic signalization:

(1) Mid-block signalized school crossings should not be considered until all other alternatives have been studied; and

(2) Mid-block traffic signals for school crossings should always be pedestrian actuated unless the signal is designed to assist in preserving platoon discipline through a progressive signal system (Institute of Transportation Engineers, 1984).

At intersections, right-turn-on-red traffic increases the likelihood of pedestrian crashes. Pedestrians crossing from the right of the driver are exposed to maximum risk because drivers focus their attention to the left prior to negotiating the turn (Florida Department of Transportation, 1992). The following recommendations were made to improve traffic signals:

(1) Pedestrian signalization should be implemented at urban signalized intersections, where field studies warrant. Pedestrian signal heads should be mounted on poles that support the push buttons so that they relate to the signal display. All signal heads should be brought up to current MUTCD standards;

(2) Where diagonal spans supporting traffic signal heads prevent pedestrians from seeing the current vehicle phase, existing span wire installation should be removed and a new traffic signal should be installed using pole/mast arm mounted signals or box spans;

(3) When the view of a driver approaching an intersection is restricted, the corner should be cleared of all sight obstructions by using joint-use poles to support traffic signals, street names, and lighting. All other items like trees and shrubs should be relocated or removed; and

(4) Whenever feasible, left turn movements at signalized intersections in downtown or commercial zones should be restricted by protective left turn phasing,

Pavement Markings–Pavement markings are used to mark pedestrian crossings and emphasize traffic control by supplementary warning and regulatory signs. All markings must conform to the MUTCD. Strict adherence to the following procedures is suggested while using pavement markings (Institute of Transportation Engineers, 1984):

(1) Pavement markings should never be used as the sole protection for children in the vicinity of schools. Pavement markings may become ineffective due to wet or snowy conditions on pavement, lack of adequate maintenance, or when hidden from the view of motorists by vehicles ahead. Markings should always supplement standard traffic signs; and

(2) Special school pavement markings should be limited to those roadways that are in the vicinity of the school grounds. The marking of roadways at considerable distances from the school grounds tends to weaken the effectiveness of such installations.

7.2.6 Lack of Pick-up and Drop-off Zones

The parents and school bus pick-up and drop-off zone is a critical element to the school site design. A good school site design should stress a maximum feasible separation of the three basic modes of transportation: (1) school bus, (2) cars and motorcycles, and (3) pedestrians and bicyclists. It is recommended in the School Trip Safety Program Guidelines published by the Arizona Department of Transportation that the two key safety principles to be rigidly adhered to are:

(1) Provision of adequate physical space for all modes of transportation to the degree that each is found on the school site or planned for in the future, and

(2) Physical routes be provided for the basic modes of transportation to school and they be separated as much as possible from each other.

As suggested in these guidelines, it is absolutely essential that bus zones be separated from all other transportation activities. An estimate of the number of buses expected to be within the loading and unloading zone at any given period of time will dictate the dimensions of the school bus loading zone. The estimation should include the total number of buses used at the school site, the number of drop-off and pick-up cycles run by each bus during its pick up and drop off period, an estimate of the duration buses will be parked in the zone during its longest period (loading or unloading), and the length of the buses to be used at the location. Two exit lanes (one each for right and left turning buses) should be provided at locations where bus loading and unloading driveways reenter the street system. Sufficient length of storage should be provided from the street exit back to the location where buses are lined up for loading and unloading. The bus loading and unloading zones should be designed for one-way movement, with the passenger door on the building or curbside. It is highly recommended that this be a counterclockwise movement.

Likewise, the movement of cars in loading and unloading zones should be in a one-way, counterclockwise direction. Cars should be parked parallel so that they do not need to back up. This counterclockwise motion guarantees that students exit the vehicle on the curbside. The student loading zones should be completely separated from the bus zones. There should never be a need for parents' cars to mingle with buses.

7.2.6 Summary

The countermeasures presented in this chapter for each of the five evaluated issues were identified through an extensive literature review of publications on school transportation safety. "3 Es" (Engineering, Education, and Enforcement) were developed in the safety program for school-aged children. Although each issue has its specific countermeasure, it is suggested that when facing any of the complicated issues of school transportation safety, a systematic analysis of the problem should be performed and all possible countermeasures involving the 3 Es be considered.

7.3 Young Drivers

This section discusses countermeasures applicable for the safety concerns of young drivers. Most countermeasures are education or enforcement related than engineering related for this population subset.

7.3.1 Education and Expanded Programs

The curriculum of the driver education programs need to be overhauled before reintroducing them to the nation's high schools. In addition to covering basic driving techniques, the goal of the program should be to help reduce risk-taking behavior of drivers and improve safety decision-making skills. Safety officials have called for the development of teaching and testing software, and the use of interactive simulators.

Parents need to assume more responsibility for training young drivers. National Highway Traffic Safety Administration (NHTSA) senior researcher, Michael Smith, believes that more parental involvement is crucial to novice drivers. They gain a lot more experience by practicing on the road with parents than they could ever get by attending classes only. "Parents may or may not be good drivers," admits Robert Foss, a highway safety research associate at the University of North Carolina, "but...they can keep their young drivers focused and serious" (Smith, 1998). Community groups, national organizations, and businesses are helping to improve communication between parents and teens.

Focus on the Future, a plan developed by the National Safety Council, seeks to consolidate teen safety efforts of many different organizations. A part of the plan, aimed at 16-24 year-old traffic offenders, is called *DDC: Alive at 25.* This National Safety Council-sponsored defensive-driving course does not include many lectures. It is a 4-hour program that encourages young people to get involved in the discussion of various issues. By the use of videos, case studies, and discussions this course helps young drivers realize and understand the consequences of taking risks. *Focus on the Future* also sponsors 'safe-driving' events at schools. Lessons on drinking and driving, safe-attitude workshops, and semi-trailer blind-spot demonstrations are some of the activities at these events. Other public symposiums feature sessions on teen violence, traffic safety, impact of the media, and cooperation of parents, teachers, students, and law enforcement in issues of traffic safety.

General Motors Corporation sponsors *Partners in Safety,* a program that helps ease the anxiety teenagers may face when driving with their parents. Using videos, booklets, and other materials, the program aims to increase the time parents spend in the car with the teens. The program is designed for use within graduated licensing, and is already in place at over 13,000 schools. Many states link high school and other driver-education programs to graduated licensing policies.

7.3.2 Graduated Licensing Programs

Graduated licensing policies are probably the most popular weapon in the battle to prevent accidents of teen drivers. These policies reinforce the notion that driving is a privilege and not a right. Over 20 states, including Florida, have already adopted graduated licensing policies. Several others are seriously considering adopting such measures. Nearly every major highway safety organization in the U.S. endorses graduated licensing. For example, American Automobile Association (AAA) advocates the installation of graduated licensing in all 50 states by the year 2000. The agency makes several suggestions and recommendations for states to consider during the development of such policies.

Under graduated licensing programs, drivers must complete a 3-step process before they are granted a full license. AAA guidelines suggest that the first level of licensing allow a 16 year-old to obtain a learner's permit after passing a written test. At this level, teens may drive during daylight hours only and must have a driver over 21 present in the car. Also, the driver is not permitted to transport any teen-aged passengers. After six months of no violations or accidents, the driver is eligible to road test for an intermediate level license. This license allows the teen to drive at night as long as a driver over 21 is present in the car. The driver is also allowed to carry a maximum of 2 teen passengers. Upon reaching the age of 18, a full license is issued to those drivers who have not had any accidents or traffic convictions during the last 12-month period. Other agencies, such as NHTSA and the National Safety Council, suggest similar rules for teen licensing. Many graduated licensing policies currently in place resemble those of AAA and other models. Graduated licensing policies typically incorporate other countermeasures such as curfews, limitations on number of passengers, zero-tolerance alcohol rules, mandatory supervised periods, and more parental involvement.

7.3.3 Driving Restrictions:

7.3.3.1 Curfew

According to the Insurance Institute for Highway Safety, 42% of the teen driving deaths occur between 9 p.m. and 6 a.m. Most graduated licensing programs, including Florida's program, place nighttime curfews on teen drivers. Usually, the only exception allowed to the curfew is when the novice driver is en route to or from work. According to Florida's curfew policy, a 16 year-old driver may not be on the streets between 11 p.m. and 6 a.m. The restricted hours for a 17 year-old are 1 a.m. to 5 a.m. Since the law took effect in 1996, the number of nighttime accidents of drivers aged between 15 and 17 has dropped by 23%. Other states such as North Carolina have similar curfew rules. North Carolina broke new ground by setting its curfew at 9 p.m. According to the University of North Carolina research scientist, Rob Foss, the curfew hour is based on the finding that 77% of novice driver crashes occur between 9 p.m. and midnight. Foss also pointed out that "recreational driving" usually started by 9 p.m. The novice driver is easily distracted when several other teens are in the car. This situation becomes worse when combined with lack of experience and poor nighttime driving skills. For this reason, most graduated licensing programs also include passenger restrictions.

7.3.3.2 Passengers

The Insurance Institute for Highway Safety pointed out that passengers accounted for about 66% of all teens killed in crashes involving young drivers. Many graduated licensing programs specify the age and number of passengers a teen driver may carry. Depending on the level of the license, the presence of an adult is required at least part of the time. Also, the level of license limits the number of teen-aged passengers allowed in a car with a teen driver. As part of its guidelines for graduated licensing programs, AAA suggests that level-one drivers have at least one adult over 21 in the vehicle at all times. This stage forbids the driver from carrying any teen passengers. Once the driver attains the intermediate level, he/she may carry a maximum of 2 teen passengers. The presence of an adult is required for nighttime driving. Upon receiving a full license, these restrictions are dropped.

7.3.3.3 Zero Tolerance

Over 37 states have enacted zero-tolerance legislation. *Zero-tolerance* is a concept designed to prevent persons under 21 from driving even if small amounts of alcohol are consumed. This is based on the fact that it is illegal for anyone under 21 to purchase, possess, or consume alcohol. There is no leniency for under-age drivers found to have alcohol in their system. Most zero-tolerance policies set a blood alcohol content (BAC) limit at 0.02%. Penalties include fines, community service, license suspensions, and completion of substance abuse programs.

7.3.3.4 Seat Belt Use

The rate of seat belt use in the U.S. was about 15% through the early 1980's. Due to the passage of seat belt legislation by 31 states, the rate of seat belt use climbed to 42% by 1987. By 1992, national campaigns to increase awareness and enforcement pushed the rate to 62%, and the current rate lies around 68%. As mentioned earlier, seat belt use among young drivers is much lower than the national average. Most efforts to increase seat belt use usually incorporate messages specifically aimed at young drivers.

The *Presidential Initiative for Increasing Seat Belt Use Nationwide*, a plan involving many agencies, seeks to raise seat belt use rates to 85% by 2000 and to 90% by 2005. Achieving these goals would help America save thousands of lives and billions of dollars; as well as prevent hundreds of thousands of injuries. Many government officials do not understand the link between seat belt use and social burdens. The Initiative sees this as one of the largest barriers to increasing seat belt use. Legislators must be made aware that the combined costs of injuries preventable by seat belt use is shared by the government, health care systems, businesses, and individuals. The Initiative is a four-point plan that seeks to build public/private partnerships to help save lives, pass tougher laws, make law enforcement more effective and visible, and improve public education about seat belt use. While teen seat belt use is not the sole focus of the plan, parts of it do address this issue.

The Department of Education is one of the key agencies participating in the Presidential Initiative. Its role is to encourage school health and safety officials to include proper seat belt use in their health and wellness programs. It is also charged with working in cooperation with NHTSA to develop a traffic safety curriculum for all grade levels, as well as promoting district seat belt use policies.

State and local enforcement agencies have also focused on teen seat belt use. While most seat belt laws are considered *secondary*, because a citation can be issued only if the driver is stopped for another violation, 11 states have passed *primary enforcement* measures. This policy allows police to stop motorists solely for seat belt use violations. Many states have included primary enforcement in teen driver legislation.

7.3.3.5 Enforcement/Punishment

Stricter law enforcement and creation of innovative punishment are some of the methods being used to reduce teen accidents. There are many supporters for these countermeasures, but are not always universally accepted. Promoters of young driver safety support more frequent traffic stops to verify licensing status, check curfew violations, ensure seat belt use, and enforce zero-tolerance limits. They urge police officers to enforce these rules strictly. Unfortunately, many police officers are reluctant to make stops and issue citations because they feel judges are lenient with young people.

In April 1995, a 16 year-old driver struck and killed a construction worker on Interstate 95 in South Florida. The teen, who fell asleep at the wheel, did not realize he had hit the worker until other motorists flagged him down over a mile later. Police charged the youth with vehicular homicide and leaving the scene of an accident. The presiding judge withheld a judgement of guilt, and instead suspended the young driver's license for 6 months, fined him $500, and ordered him to attend driving school.

Many other alternate forms of punishment have been used to change the behavior of teen drivers. In Los Angeles and other cities, the court orders some young offenders to tour the morgue. They must also watch a graphic video and relate their experiences. Similar measures include mandatory tours of emergency rooms and rehabilitation clinics. Another idea is to have teen juries decide cases involving teen offenders.

7.3.3.6 Case Studies

Ontario, Canada began a very specific graduated licensing program in 1994. Young drivers start off with a G1 permit after passing written and vision tests. Under this permit, a fully licensed driver with at least 4 years of experience is required to be in the front seat at all times. This person must have a BAC lower than 0.05%, while the driver's BAC must be zero.

7.4 International Tourists

Several improvements are suggested as countermeasures to the identified critical safety issues of international tourists. Most of the critical issues are however inter-related. Hence, instead of discussing countermeasures separately for each issue and concerns, they are discussed in general. It was also noted that most of the problems and hence the countermeasures are related to traffic signs.

7.4.1 Signage Related Improvements

Exit Signage on Limited Access Roads: Exit signage on limited access roads needs to be improved in several ways. While considering signage on limited access roads, the most prevalent problem experienced by international tourists was the need for better advance warnings of upcoming exits. An international tourist traveling on the interstate system looks for an exit to take him/her to their intended destination. In such situations, European visitors are familiar with three warnings. Often in Florida there is just one advance guide sign indicating the exit and hence creates a safety problem. This situation is more serious in left exit conditions as international tourists, travelling slower than the rest of the traffic, in the right-most lane are put at risk. Hence, more advance signs are recommended especially in places with high percentages of tourist travel and presence of left exits.

Better Destination Signing: Rather than cardinal directions international tourists depend heavily on destination keys. Since tourist attractions and locations are not typically listed on the signs on the limited access routes, international tourists have problems matching route numbers or name and cardinal directions with their intended destination. This problem is amplified when faced with just one opportunity to assimilate the necessary information on the interchange advance guide signs. Also, particular attention should be paid to providing better destination signage to airports and car rental agencies.

Improving Consistency in the use of Route Name/Number: Inconsistencies in the usage of route name and number for the same route has proved problematic for international tourists, particularly on tolled roads. Using the same number or name in all applications, such as on guide signs, maps and also verbally is particularly important in ensuring the safety of international drivers.

Use of More Symbols within the Road Signs: This problem was suggested to be easily anticipated with the international signage practice of using symbols and the U.S. reliance words. The current Manual on Uniform Traffic Control Devices (MUTCD) does use more symbology, in particular with the warning, general information, and recreational and cultural interest signs. International tourists, particularly Europeans are more accustomed to symbols on road signs. Hence deployment of additional symbols within the road signs will assist in achieving better understanding of road signs among international tourists. This step will essentially help those tourists who are not familiar with the English language.

More Use of Diagrammatic Signs: The international sign system in relation to its dependence on symbology rather than words uses diagrammatic signs for guidance on all classes of roads. International tourists are therefore accustomed to navigating by such signs. Diagrammatics have the added benefit of showing the general direction and geometry of the upcoming route in relation to the current travel route and hence are suggested as a countermeasure in increasing the safety of international tourists.

7.4.2 Educational Countermeasures

The other type of countermeasure that will assist international tourists when traveling on unfamiliar roadways is education. Even though it is not possible to provide a completely familiar driving experience for visitors from throughout the world, a coordinated effort has been recommended by Wilbur Smith Associates to educate the international tourists about driving laws, customs and conditions in Florida. This will require a multi-disciplinary approach in coordination with the other state and local agencies as well as the tourism industry.

A professional video should be produced that will introduce international visitors to Florida roadway conditions, traffic control procedures (signs, signals, and markings), customs, traffic laws and safety tips. This video may be produced in several languages and could be distributed for viewing to those airlines that provide direct international service to Florida.

Also, developing and operating official tourist information centers at airports and rest areas in the interstates will be extremely useful to the tourists. Available technology should be used to install interactive computers that provide navigational services and information about tourist attractions, hotels, and restaurants.

The aforementioned countermeasures are summarized in a matrix form for a better understanding as one countermeasure is sometimes capable of addressing several identified issues. Thus, a countermeasure matrix for international tourists is given in Table 7.7.

7.4 People with Disabilities

The Committee on Specialized Transportation of the Transportation Research Board held a targeted workshop in 1991 designed to identify a framework of key policy issues and research and development needs. The workshop identified a total of 13 key policy issues from four policy areas and related research and development needs to address these issues. These issues and countermeasures are discussed below and summarized in Table 7.8.

Information, Legislative, and Regulatory Issues:

(1) No standard and scientifically sound method of license recall exists for people with progressive disabilities. We need to be able to identify when progressive disabilities are likely to interfere with safe driving. We also need to identify accurate and equitable methods of evaluating the deterioration in people's driving skills, to standardize them, and to make them available to policy makers of driver licensing.

(2) Information concerning private vehicle transportation for people with disabilities is not available to consumers, suppliers, government, and others. Research needs to be conducted to determine missing information and the effects of making this information more widely available. Widely available information would allow government agencies, suppliers of equipment, and other organizations to benefit from the experience of consumers, suppliers, evaluators, and others.

(3) The private vehicle modification industry is largely an unregulated market. A sound profile of the vehicle modification industry needs to be developed, to document the quality and performance of its services and products, and to determine the necessity of regulatory control.

Table 7.7: The Countermeasure Matrix for the Safety Issues of International Tourists

Countermeasure / Issue/Concern	Better Information on Signs	Information Sessions Brochures etc.	Development of new Signs	Size and Location Changes of Signs	Avoid Confusing/ Misleading Text on Signs
Unfamiliar with Roadway System	X	X			
Unfamiliar with Driving System		X			
Difficulty Recognizing and Understanding Traffic Signs	X		X	X	X
Lack of Information about Driving laws and Customs in US	X	X	X		
Confusion in Translating English into Metric Distance on Signs	X	X	X		

Table 7.8: Summary of Policy Issues and Countermeasures

Areas	Issues	Countermeasures
Information, Legislative and Regulatory	No standard method of recalling licenses from people with progressive disabilities	Research and develop methods for evaluation and license recall
	Poor information flow between consumers, suppliers, government	Research and develop methods to facilitate communication
	Lack of regulation of safety standards in the production of adaptive equipment	Research ways to develop standards
Driver Assessment, Education, and Licensing	Insufficient standardization of driver assessment and testing criteria for people with disabilities	Research and develop systematized tests and evaluation methods
	No standardized training or course materials for instructors who conduct driver assessments for people with disabilities	Research and develop a standard syllabus and training system
	Driver evaluation and assessment technology has not kept pace with bio-medical and vehicle technology	Research and develop a plan to bring these technologies into balance
Vehicle Design, Adaptive Equipment Standards and the Driving Environment	Insufficient standardization of adaptive equipment and specifications for vehicle modification	Develop standards and specifications
	Lack of disability related design at the concept stage of automobile and van design	Research methods to make vehicle designers aware of people with disabilities as a market for vehicles
	Lack of standardized procedures for testing new products for people with disabilities, e.g., crash dummies do not exist	Develop procedures for testing equipment for people with disabilities
	Incompatibility between adaptive vehicle modification and automotive engineering	Research and develop methods to increase compatibility
	Need for a national emergency network for drivers with disabilities	Research and coordinate a comprehensive national network
Funding Needs and Sources	Standardized procedures for testing products for drivers with disabilities is not affordable by the private sector alone	Identify sources of public funds to subsidize testing of new products
	Need to identify methods of subsidizing vehicle and adaptive equipment purchases for people with disabilities	Research and compare mechanisms for subsidy, including tax breaks, low interest loan and rebates

Source: TRB (1993). Private Vehicle Access for People with Disabilities, Transportation Research Circular 415, Washington, D.C.: National Research Council.

(4)

Driver Assessment, Education, and Licensing:

(1) Standardization of methods and criteria is insufficient for testing the driving ability of people with disabilities. An appropriate basis for standard methods and criteria needs to be determined, both in terms of techniques and the ability of these functional areas measured by the techniques to reveal an individual's ability to drive safely.

(2) Standard syllabi and training materials for instructors, who assess drivers with disabilities, needs to be developed. These materials would take into account standard methods and criteria for testing the driving ability of people with disabilities.

(3) In order to narrow the gap between driver evaluation and assessment of bio-medical and vehicle technology, useful medical and vehicle advances needs to be identified to evaluate the potential in improving our driver assessment methods.

Vehicle Design, Adaptive Equipment Standards, and the Driving Environment:

(1) Few standards exist for the equipment to be used in vehicles driven by people with disabilities. As equipment for private vehicle adaptation is often provided by a competitive tendering process, bidders have an incentive to reduce the cost of equipment to win the bid. Existing standards would ensure that the equipment meets the specified safety requirements. Further, accident history data would be very useful to the agencies that establish standards.

(2) Potential size of the market needs to be established to encourage vehicle manufacturers to consider the needs of people with disabilities. It is also necessary to define features that could be incorporated into new vehicles that would benefit people with disabilities either directly or indirectly facilitating later vehicle modification.

(3) Crash dummies, representing able-bodied people, are used to test the safety of new vehicles. The extent of deficiency in the final products offered to people with disabilities

needs to be determined. If the crash dummies cause deficiencies, the parameters of test devices that would provide more appropriate testing of products needs to be defined.

(4) There is a need to develop a national emergency aid network for drivers using adapted private vehicles. This service would assist in rescuing stranded individuals and render those services to the specialized vehicles that the normal automobile service network would not be able to provide.

7.6 New Immigrants

The three basic types of countermeasures to address the unique highway safety issues of new immigrants are improved data collection, education, and roadway sign changes. The standard forms used to collect highway crash data do not identify whether persons involved are new immigrants. Extensive data is needed to examine the seriousness of safety problems associated with new immigrants. In areas where a significant portion of the population are new immigrants, changes in the language of roadway signs may be a countermeasure, while such changes are inappropriate elsewhere.

The sole study concerning highway safety needs of Hispanic immigrant communities identifies education as a primary countermeasure (NHTSA, 1991). The following discussion is based on the strategies recommended in that study.

Focus group participants and telephone respondents of government organizations expressed support for promotional programs that are highly personalized, family-oriented, culturally sensitive and relevant, and non-confrontational. Most often, focus group participants mentioned personal contact and relationships as important strategies. They pointed out that graphic and explicit depictions of motor vehicle crashes are an effective method of conveying the message to families. Also emphasized was the importance of developing and maintaining cultural sensitivity to the diverse groups of new immigrants. Promotional efforts can be carried out in various ways, including community-based organizations, churches, schools, families, and the media that target immigrants.

Community-Based Organizations:

Participants mentioned several features of community-based organizations that are good for safety promotion. Community-based organizations often provide services to low or moderate income households at little or no cost, have staff who speak the language of the immigrant and are culturally sensitive. Based on the opinions of telephone and focus group participants, it was found that outreach activities sponsored by community-based organizations are successful. For example, the Century Council in Los Angeles has organized traffic safety campaigns around traditional and popular Hispanic festivities. The direct outreach strategies included setting up booths with traffic safety information as well as distributing pledge cards that individuals sign promising to stop unsafe behavior.

Churches:

Participants of all ages are receptive to traffic safety programs through churches because they are trusted and accessible. Highway safety organizations in Florida and Texas have engaged in partnerships with the church. The Community Alliance for Training and Safety in San Antonio, Texas has enlisted priests to include safety themes in masses. In many areas, church-related organizations are one of the principal agencies that provide service to recent immigrants.

Schools:

School-based programs are often effective in promoting highway traffic safety because both parents and children respect teachers and the educational system. Some of the examples from the focus group participants are listed below:

(1) According to participants in McAllen, Texas schoolteachers do traffic safety education by taking the children to see the court system and the jails, and teachers are assisted in this effort by the police department.

(2) Women participants in the Rio Grande Valley, Texas, pointed out that community schools are good for educating adults in traffic safety. Currently, the only places that

offers driving classes are specialty-driving schools, at a price of $200. All the participants agreed that the price was beyond their means and that they would be willing to pay a lower price for the classes. Also, they expressed an interest in taking driving lessons to improve driving skills and learn traffic laws. Such classes would be a good forum for them to learn from each other by sharing their experiences behind the wheel.

(3) Adolescent male participants in the District of Columbia recommended that the driver education programs be made available at schools. Traffic safety professionals need to be recruited to teach young people and others in the community. Driver education courses should be offered to those who are interested in learning traffic safety. One of the methods used to ensure active participation is presentations by people who have had crashes in the past.

Family:

The family is one of the most powerful symbols in the immigrant communities. Anything that is viewed as a danger to the family is more effective in reaching the entire community. Participants emphasized that any public awareness campaign for these communities must feature the family. For example, grandmothers have been used in child safety messages by some organizations because they are often the true family educators. Instead of presenting statistics alone, the participants suggested that the data be presented with an emphasis on its implications on the family unit.

Media:

In areas with a high concentration of immigrants, there is often a variety of print and electronic media that target the immigrants. Study participants agreed that the creative use of both English media and the media of the immigrants' language is essential to any effort to promote traffic safety.

Study participants viewed television as the best medium for disseminating traffic safety information to immigrant populations, especially in urban areas. The Century Council in Los Angeles has used television extensively in its traffic safety campaigns. Channel 32, a

Spanish Network in Los Angeles, broadcasts a traffic safety segment on a morning talk show at least once every three months. In a segment on infant safety seats, they explained the consequences of not having children in safety seats while driving. Also, they showed correct ways to buckle children in safety seats and offered information on obtaining child safety seats. In addition, participants viewed *Rescue 911*, *COPS*, and other reality-based shows as ideal teaching mechanisms. Television is often seen as the medium with the most potential for public service announcements on traffic safety.

While radio may not be as effective as television in promoting traffic safety, it is however more widespread in terms of the number and ways people can access information. The *El Guardian* program in San Jose, California uses radio on a weekly basis to discuss an array of traffic safety issues. In addition to television and radio, newspapers also play a role in promoting traffic safety for immigrant communities. *El Observador* in San Jose publishes a monthly supplement providing information on traffic safety issues, in addition to health and other community issues. Study participants also indicated that the government should place safety announcements and stories in dailies.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 SUMMARY

Selection of special population groups and their corresponding issues/concerns were achieved from results of a statewide survey of transportation safety professionals. Obtaining a high response rate for both surveys was a difficult task, but one that was accomplished through persistent follow-up. Highway safety experts ranked (in order of highway safety importance) older drivers, school-aged children, young drivers, disabled people, international tourists, and new immigrants as the special population groups requiring further attention. Each special population group was studied and their critical issues and concerns identified through a multi criteria decision making approach. The factors taken into consideration were: 1) impact of the issue on crash rate; 2) effectiveness of roadway design changes on addressing the issue; 3) effectiveness of policy changes on addressing the issue; 4) cost of implementing roadway design or policy change; 5) ease of implementation; and 6) priority to address the issue. Three different approaches were used to assign weights to each factor. The final ranking of the issues and concerns was performed on the basis of considering an index of weighted averages. According to the findings, the most critical issue/concern for older drivers was identified to be 'location and size of traffic signs and lettering'. Nighttime visibility and perception reaction times were the second and third most important issues, respectively. These were followed by gap acceptance capabilities, deficiencies in driving knowledge, narrow lanes, driving in congestion, maneuvering curves, and freeway driving in that order. Similar rankings were obtained for other special population groups as well.

Detailed investigation was conducted on the identified critical highway safety issues of the special population groups. Most of the analysis was based on past studies, using relationships between speed, injury severity, and traffic volume. Injury severity for school aged children was established by collecting data on pedestrian/bicycle crashes. Countermeasures were then provided and discussed in detail for the critical issues/concerns identified from each special population group. Since some of the countermeasures are capable of addressing more than one issue, the findings were summarized in matrix form whenever it was possible.

Projection models were developed in this study, so that crash rates for some of the special population groups can be estimated at any time point within the study horizon. The time period in this study extended until the end of Year 2010. Two sets of models were developed (one for the state of Florida and the other at the national level). Among the several different model formats tested, negative exponential provided the best fit to the data with R^2 values ranging from 0.784 to 0.974.

8.2 CONCLUSIONS

The findings of this study are extremely useful in taking steps towards improving the highway safety not only of the selected six special population groups, but the overall population as well. Due to the limitations in various associated factors, it is not possible to address all the critical issues and concerns at the same time. In this regard, a ranking of the issues would be quite useful. Issues with higher ranking were most important, and accordingly were first addressed. Detailed analysis of the critical issues and concerns will provide a better understanding of the type of problem encountered. Countermeasures necessary in addressing a corresponding issue were identified in this study, and summarized in the form of matrices.

The projection models developed in this study help in identifying the most critical groups for today's transportation situation but also in the future as well. Fatality and/or crash rate for each special population group are estimated for the entire United States or the state of Florida by substituting the year for which the crash rate is being estimated. These models provide a simple approach, as opposed to other models that consider a large number of independent variables. Due to the lack of statistics, it was not possible to develop models for all six special population groups considered in this study. This difficulty was more pronounced in the case of new immigrants, and to a lessor extent, observed in the cases of people with disabilities and international tourists. Most crash reports do not identify whether the crash victim is a new immigrant, making it impossible to perform any kind of analysis on the highway safety problem for this group.

8.3 RECOMMENDATIONS

For each identified issue/concern, countermeasures were suggested in this study. However, it is necessary to identify the most effective countermeasure in addressing each of the issues/concerns. It would be also useful if knowledge of the benefits of a specific safety countermeasure could be obtained prior to implementation. Thus, the second phase of this project evaluates some of the suggested countermeasures. A performance parameter is selected for each individual issue by field measurement, under two different conditions ('with' and 'without' the countermeasure), allowing for a final evaluation. This evaluation assists the decision-maker (highway safety engineer) in determining the most effective approach. In addition, the effects of certain countermeasures are evaluated using the Florida Traffic Crash Database. This is achieved by analyzing crash statistics 'with' and 'without' the countermeasure when all other conditions are expected to remain the same.

The database used in the model building process for school-aged children was found to be unsatisfactory. In order to obtain better models of the relationship between vehicular speed, traffic volume, and crash severity of school-aged children pedestrian/bicyclist, it is essential that the database is expanded and the necessary information obtained.

In the future, greater attention should be paid by relevant authorities to modify crash reports so that more detailed information could be gathered. However, such changes should only be carried out under careful consideration and detailed investigation. The projection models developed in this study were based on the compilation of statistical data obtained from various publications. If current crash databases were searched for the same figures, more accurate values would have been achieved. The authors recommend repeating the modeling process with values from an actual crash database to determine whether the accuracy of the models could be improved.

REFERENCES

Balts, M.R., *Measuring Motorist Comprehension of Florida's School Bus Stop Law and School Bus Signalization Devices*, TRB Preprint, Transportation Research Board, Washington D.C., January 1998

Benekohal, R. F., Michaels, R.M., Resende, P. T. V., and Shim, E., *Highway Design and Traffic Operations Needs of Older Drivers,* TRB Preprint, 940722, Transportation Research Board, Washington, D. C., January 1994

Benekohal, R. F., Michaels, R.M., Shim, E and Resende, P. T. V., *Effects of Aging on Older Drivers' Travel Characteristics,* TRB Preprint, 940722, Transportation Research Board, Washington, D. C., January 1994

Better Living for Seniors, Florida Department of Health and Rehabilitative Services, 1989

Brown, I., Predisposing factors in the Alcohol and Drug-Impairment of Young Drivers' Performance. *Young Drivers Impaired by Alcohol and Drugs*, 1986

Cerrelli, E. C., *Crash Data and Rates for Age-Sex Groups of Drivers, 1996*, Research Note, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington D.C., January 1998

Chu, X., *The Effects of Age on the Driving Habits of Elderly: Evidence from the 1990 NPTS*, Center for Urban Transportation Research, College of Engineering, University of South Florida, October 1994

Dickinson F. O., *Special Report on Driver Age Differences in Traffic Crashes,* Florida Department of Highway Safety and Motor Vehicles, March 1995

Estimating the Number of Vehicles Adapted for Use by Persons with Disabilities. NHTSA, U.S. Department of Transportation, 1997

Estimating the Number of Vehicles Adapted for use by Persons with Disabilities, Research Note, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington D.C., December 1997

Evaluation of International Signing Practices, Final Report, Florida Department of Transportation and Wilbur Smith Associates, Volume 1 and 2, November 1994

Evaluation of International Signing Practices: Volume 1. Final Report. Wilbur Smith Associates, and Florida Department of Transportation, Office of Traffic Operations, 1994

Evans, L, *Future Predictions and Traffic Safety* Research, *Transportation Quarterly,* Volume 47, No.1, January 1993, pp. 3-18

Fambro, D. B., Koppa, R. J., Picha, D. L., and Fitzpatrick K., *Driver Perception-Brake Response in Stopping Sight Distance Situations,* TRB Preprint No. 981410, Transportation Research Board, Washington D.C., 1998

Florida Pedestrian Safety Plan, Florida Department of Transportation, 1997

Florida School Bus Occupant Safety, Center for Urban Transportation Research, University of South Florida, 1993

Florida Statistical Abstract 1997, Bureau of Economic and Business Research, College of Business Administration, University of Florida, 1997

Florida Traffic Crash Facts, Years 1985 - 1996, Florida Department of Highway Safety and Motor Vehicles, Tallahassee, Florida

Florida Visitor Study 1996, Florida Tourism Industry Marketing Corporation, 1997

Graham, J. R., Fazal, A., and King, L. E., *Highway Sign Minimum Luminance Requirements for Older Drivers,* TRB Preprint 970079, Transportation Research Board, Washington D.C., January 1997

Haight, F.A. *A Method for Comparing and Forecasting Annual Traffic Death Totals,* Transportation Research Record 1238, TRB, National Research Council, Washington, D.C., 1989, pp.31-36

Hakim, S. D., Shefer, A.S., Hakkert and I. Hocherman, *A Critical Review of Macro Models for Road Accidents,* Accident Analysis and Prevention, Vol.23, No. 5, 1991, pp.379-400.

Hall, H. W., *Highway Engineering Improvements to Accommodate Older Drivers,* ITE Compendium of Technical Papers, Institute of Transportation Engineers, 1990, pp. 283-286

Hawkins, H. G., Picha, D. L., Mann, B. L., McIlroy, C. R., Womack, K. N., and Dudek, C. L., *Assessment of Mexican Driver Understanding of Existing Traffic Control*

Devices used in Texas, Research Report No. 1274-1, Texas Transportation Institute, The Texas A & M University System, November 1996

Highway Safety Needs of U.S. Hispanic Communities: Issues and Strategies. NHTSA, U.S. Department of Transportation, Washington, D.C.: 1995

Highway Statistics Summary to 1995, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Home-to-School Transportation Study, Center for Urban Transportation Research, University of South Florida, 1993

Khavanin, M. R., and Schwab, R. N., *Traffic Sign Legibility and Conspicuity for Older Drivers*, ITE Compendium of Technical Papers, Institute of Transportation Engineers, 1991, pp. 11-14

Lerner, N. D., *Age and Driver Perception- Reaction Time for Sight Distance Design requirements*, ITE Compendium of Technical Papers, Institute of Transportation Engineers, 1995, pp. 624-628

Lerner, N. D., *Older Driver Perception-Reaction Time and Sight Distance Design Criteria*, ITE Compendium of Technical Papers, Institute of Transportation Engineers, 1991, pp. 6-10

Lu, J. J., and Dai, j., *The Impact of Driving Behavior of Older Drivers on Intersection Capacity*, Research Report by Department of Civil and Environmental Engineering, University of South Florida, July 1997

Manual on Uniform Traffic Control Devices, Federal Highway Administration, 1988

Marin, Gerardo and Barbara VanOss Marin (1991), *Research with Hispanic Populations*. Vol 23, Applied Social Research Methods Series, Newbury Park, CA: Sage Publications.

McCoy, P. T., Tarawneh, M. S., Bishu, R. R., Ashman R. D., and Foster, B. G., *Evaluation of Countermeasures for Improving the Driving Performance of Older Drivers*, TRB Preprint No. 930290, Transportation Research Board, Washington D.C., January 1993

National Transportation Statistics 1997, Bureau of Transportation Statistics, US Department of Transportation, Washington D.C., 1997

Nationwide Personal Transportation Survey: 1990 Databook, Volume 1, U.S. Department of Transportation, Federal Highway Administration, pp. 3-18

Nayor, D. W., and Graham, J. R., *Intersection Design Decision/ Reaction Time for Older Drivers*, TRB Preprint No. 970181, Transportation Research Board, Washington D.C., January 199

Owens, A. D., and Andre, J. T., *Selective Visual Degradation and the Older Driver*, IATSS Research, Vol. 20, No. 1, 1990

Partyka, S. C., Simple Models of Fatality Trends using Employment and Population Data, *Accident Analysis and Prevention*, Volume 16, No. 3, 1984, pp. 211-222

Partyka, S.C. Simple Models of Fatality Trends Revisited Seven Years Later. *Accident Analysis and Prevention*, Volume 23, No. 5, 1991, pp. 423-430

Private Vehicle Access for People with Disabilities: Policy Issues, Options, and Research, Transportation Research Circular 415, National Research Council, Transportation Research Board (1993).

Safety Issues for Vehicle Adapted for Use by Persons with Disabilities. Research Note, NHTSA, U.S. Department of Transportation, 1998

Sivak, M. A. 1975 Forecast of the 1985 Traffic Safety Situation: What Did We Learn From an Inaccurate Forecast. *Road Users and Traffic Safety*, 1987, pp. 13-25

Sivak, M. Society's Aggression Level as a Predictor of Fatality Rate. *Journal of Safety Research*, Volume 14, 1983, pp. 93-99

Smeed, R. J., *Some Statistical Aspects of Road Safety Research*, Journal of the Royal Statistical Society, Series A, Volume 112, 1949, pp. 1-23

Statistical Abstract of the United States, The National Data Book, Economics and Statistics Administration, Bureau of Census, U.S. Department of Commerce, 1997

Tan, T., *Increasing Highway Sign Legibility for Older Drivers*, TRB Preprint No. 920711, Transportation Research Board, Washington D.C., January 1992

Transportation in an Aging Society: Improving Mobility and Safety of Older Persons, Transportation Research Board, National Research Council, TRB Special Report 218, Volume 1 and 2, 1988, Washington D.C.

Transportation Statistics Annual Report 1997, Bureau of Transportation Statistics, U.S. Department of Transportation, *Wheelchair Users Injuries and Deaths Associated with Motor Vehicle Related Incidents,* Research Note, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington D.C., September 1997

Yi, P., *Gap Acceptance for Elderly Drivers on Rural Highways*, ITE Compendium of Technical Papers, Institute of Transportation Engineers, 1996, pp. 299-303

Appendix 1

Special Population Safety Survey

Survey Form A (One page)

Six special population groups have been identified.Other population groups may be added at the bottom.
Please indicate the importance of highway safety concerns for each population by only marking one box for each group.

		No Opinion	Less Important 1	2	3	4	More Important 5
1	Older Drivers	☐	☐	☐	☐	☐	☐
2	International Tourists	☐	☐	☐	☐	☐	☐
3	School Aged Children	☐	☐	☐	☐	☐	☐
4	Young Drivers	☐	☐	☐	☐	☐	☐
5	New Immigrants	☐	☐	☐	☐	☐	☐
6	Disabled People	☐	☐	☐	☐	☐	☐
7	**Others : (please specify)**	☐	☐	☐	☐	☐	☐

Survey Form B (6 pages)

For each of the six special population groups, please indicate the rating of importance for identified issues regarding the highway safety. (Mark only one rating for each issue)

1. OLDER DRIVERS

		No Opinion	Less Important 1	2	3	4	More Important 5
1	Night time Visibilities	☐	☐	☐	☐	☐	☐
2	Difficulties in understanding the Changeable highway messages	☐	☐	☐	☐	☐	☐
3	Deficiencies in Driving Knowledge	☐	☐	☐	☐	☐	☐
4	Dimensions of Signs and Lettering	☐	☐	☐	☐	☐	☐
5	Location of the Traffic Signs	☐	☐	☐	☐	☐	☐
6*	Perception Reaction Time	☐	☐	☐	☐	☐	☐
7**	Start-up lost time and Saturation Headway at Signalized intersections	☐	☐	☐	☐	☐	☐
8***	Gap acceptance capabilities at stop controlled intersections	☐	☐	☐	☐	☐	☐
9	Other Important Issues/concerns: (Please specify them)	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

* If there is an obstruction to the movement of the vehicle, the time taken by the driver to see it and take necessary action is known as perception reaction time.

** At a signalized intersection, time lost in initiating the movement of vehicles when the signal turns from red to green is the start up lost time.

*** Minimum possible headway between two successive vehicles is the saturation headway. At a stop controlled intersection, minor street drivers will have to wait for a suitable gap between successive vehicles traveling on the major street. The gap size acceptable for each individual explains the Gap Acceptance Capabilities

2. INTERNATIONAL TOURISTS

		No Opinion	Less Important 1	2	3	4	More Important 5
1	Unfamiliarity with Roadways	☐	☐	☐	☐	☐	☐
2	Unfamiliarity with the driving system (e.g.. Right hand side/Left hand side)	☐	☐	☐	☐	☐	☐
3*	Recognition of Traffic Signs	☐	☐	☐	☐	☐	☐
4**	Confusion of traffic Guide signs	☐	☐	☐	☐	☐	☐
5	**Other Important Issues/concerns:** (Please specify them)	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

* Although the traffic signs are uniform in US, international tourists may not be able to correctly interpret or promptly response to some traffic signs. Typical problems include understanding of words and symbols abbreviations and connotations of words, order of information cardinal directions etc.

** Traffic guide signs in large cities may confuse international tourists. Because of deficiencies in existing guide signs, international tourists may become lost or confused while driving in major cities.

3. SCHOOL AGED CHILDREN

		No Opinion	Less Important 1	2	3	4	More Important 5
1	High traffic volumes around school zones	☐	☐	☐	☐	☐	☐
2	High vehicular speeds in and around school zones	☐	☐	☐	☐	☐	☐
3	Not enough school crossing guards	☐	☐	☐	☐	☐	☐
4	Lack of traffic and bicycle safety education programs	☐	☐	☐	☐	☐	☐
5	Lack of "Traffic Calming" devices such as speed humps, raised pedestrian medians etc	☐	☐	☐	☐	☐	☐
6	Lack of pick up and drop off zones , side walks, traffic lights etc.	☐	☐	☐	☐	☐	☐
7	Lack of proper signage, signals (walk- don't walk)	☐	☐	☐	☐	☐	☐
8	**Other important issues/concerns:** (Please specify them)	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

4. YOUNG DRIVERS

		No Opinion	Less Important 1	2	3	4	More Important 5
1	General lack of driving experience	☐	☐	☐	☐	☐	☐
2	General recklessness	☐	☐	☐	☐	☐	☐
3	Lack of driver training programs	☐	☐	☐	☐	☐	☐
4	Risk taking behavior/agressiveness	☐	☐	☐	☐	☐	☐
5	Impaired driving (Alcohol & Drugs)	☐	☐	☐	☐	☐	☐
6	Speeding	☐	☐	☐	☐	☐	☐
7	Teen cruising	☐	☐	☐	☐	☐	☐
8	lack of safety belt use	☐	☐	☐	☐	☐	☐
9	**Any other issues/concerns:** (Please specify them)	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

5. NEW IMMIGRANTS

		No Opinion	Less Important 1	2	3	4	More Important 5
1	Unfamiliarity with the driving system (eg.Left/Right handside driving	☐	☐	☐	☐	☐	☐
2*	Differences in the transportation system	☐	☐	☐	☐	☐	☐
3**	Language barriers	☐	☐	☐	☐	☐	☐
4***	Cultural differences	☐	☐	☐	☐	☐	☐
5	Inadequate/improper driving education (eg.learing through another Immigrant)	☐	☐	☐	☐	☐	☐
6	**Other issues/concerns:** (Please specify them)	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

* New immigrants may be used to roadways with low traffic speed and higher vehicle mixes. Higher vehicular speeds might bring a fear to new immigrants and hence can reduce the self confidence.

** Non English speaking immigrants face language barriers in all aspects of their daily life including their interaction with the transportation system. This may cause them to take longer time to recognize traffic signs or warnings or even fail to understand them. These barriers may also prevent public campaigns on safety issues from reaching them.

*** New immigrants usually come from very different cultures. Some cultures may not place high priority on traffic safety issues as in America.

6. PEOPLE WITH DISABILITIES

		No Opinion	Less Important 1	2	3	4	More Important 5
1	Unsafe access to transportation facilities	☐	☐	☐	☐	☐	☐
2*	Lack of policies for recalling driving licenses from people with progressive disabilities	☐	☐	☐	☐	☐	☐
3	Lack of standards for vehicle modification that are need to be used for disabled	☐	☐	☐	☐	☐	☐
4	Default designs in roadways and intersections	☐	☐	☐	☐	☐	☐
5	Lack of crossing devices for blind people	☐	☐	☐	☐	☐	☐
6	**Other issues/concerns:** (Please specify them)	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

* There is no standard or scientifically sound (and fair) method for driving license recall for people with progressive disabilities.

Appendix 2

SURVEY OF TRAFFIC SAFETY NEEDS OF SPECIAL POPULATION GROUPS IN FLORIDA

The purpose of this survey is to collect information on highway safety needs of special population groups in Florida. This information is critical in helping to shape new safety design standards, engineering practices, and safety policy. A survey conducted by the Center for Urban Transportation Research (CUTR) and the Department of Civil and Environmental Engineering in July 1997 identified the following special population groups and corresponding issues specific to each group. We need your assistance in rating the importance of each issue specific to the special population group. Please take the time to complete the survey. You can fax your completed survey to Dr. J. John Lu at (813) 974-5168 or mail it to CUTR, 4202 E. Fowler Ave., CUT 100, Tampa, Florida 33620. *Thank you for your assistance!*

Special Population: Older Drivers

Issues/concerns affecting the safety of older drivers.	1. In your opinion, what impact do these issues have on crash/accident rate? (Check one)	2. In your opinion, how effective would it be to use roadway design changes to address each of these issues? (Check one)	3. In your opinion, how effective would it be to use policy changes to address each of these issues? (Check one)	4. In your opinion, how costly would it be to implement a design or policy change to address each issue? (Check one)	5. In your opinion, how easy would it be to implement the change? (Check one)	6. In your opinion, how much of a priority is it to address each issue/concern? (Check one)
	No Impact … High Impact	Not effective … Highly effective	Not effective … Highly effective	Not costly … Very costly	Not easy … Very Easy	Not a priority … High priority
Night time visibility	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Driving in congestion	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Freeway driving	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Maneuvering curves	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Deficiencies in driving knowledge	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Location and size of traffic signs and lettering	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Perception/reaction times*	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Gap acceptance (merging into traffic flow)	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Narrow lanes (<12	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5

Note: *If there is an obstruction to the movement of the vehicle, the time taken by the driver to see it and take necessary action is known as perception/reaction time.

Special Population: School-Aged Children

ssues/concerns ffecting the safety f school-aged hildren	1. In your opinion, what impact do these issues have on crash/accident rate? (Check one)	2. In your opinion, how effective would it be to use roadway design changes to address each of these issues? (Check one)	3. In your opinion, how effective would it be to use policy changes to address each of these issues? (Check one)	4. In your opinion, how costly would it be to implement a design or policy change to address each issue? (Check one)	5. In your opinion, how easy would it be to implement the change? (Check one)	6. In your opinion, how much of a priority is it to address each issue/concern? (Check one)
	No Impact … High Impact	Not effective … Highly effective	Not effective … Highly effective	Not costly … Very costly	Not easy … Very Easy	Not a priority … High priority
igh traffic volumes round school zones	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
peeding in and round school zones	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of drop off and ick up zones	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of traffic alming devices	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of proper ignage and traffic ignals	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of sidewalks nd bike routes	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of traffic and icycle safety rograms	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of school rossing guards	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of parental uidance	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5

Issues/concerns affecting the safety of young drivers.	impact do these issues have on crash/accident rate? (Check one) No Impact – High Impact	effective would it be to use roadway design changes to address each of these issues? (Check one) Not effective – Highly effective	effective would it be to use policy changes to address each of these issues? (Check one) Not effective – Highly effective	costly would it be to implement a design or policy change to address each issue? (Check one) Not costly – Very costly	easy would it be to implement the change? (Check one) Not easy – Very Easy	much of a priority is it to address each issue/concern? (Check one) Not a priority – High priority
Lack of driving experience	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Reckless/aggressive driving	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Speeding	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Impaired driving (alcohol and drugs)	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Lack of safety restraint use	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Lack of driver training programs	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Immaturity	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5

Special Population: People with Disabilities

Issues/concerns affecting the safety of persons with disabilities	1. In your opinion, what impact do these issues have on crash/accident rate? (Check one) No Impact – High Impact	2. In your opinion, how effective would it be to use roadway design changes to address each of these issues? (Check one) Not effective – Highly effective	3. In your opinion, how effective would it be to use policy changes to address each of these issues? (Check one) Not effective – Highly effective	4. In your opinion, how costly would it be to implement a design or policy change to address each issue? (Check one) Not costly – Very costly	5. In your opinion, how easy would it be to implement the change? (Check one) Not easy – Very Easy	6. In your opinion, how much of a priority is it to address each issue/concern? (Check one) Not a priority – High priority
Unsafe access to ransportation acilities	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of policies for ssuing or recalling lriver's licenses	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ack of standards for ehicle modifications equired for disabled	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
aulty designs in oadways and ntersections	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5

Special Population: New Immigrants

sues/concerns fecting the safety new immigrants	1. In your opinion, what impact do these issues have on crash/accident rate? (Check one)	2. In your opinion, how effective would it be to use roadway design changes to address each of these issues? (Check one)	3. In your opinion, how effective would it be to use policy changes to address each of these issues? (Check one)	4. In your opinion, how costly would it be to implement a design or policy change to address each issue? (Check one)	5. In your opinion, how easy would it be to implement the change? (Check one)	6. In your opinion, how much of a priority is it to address each issue/concern? (Check one)
	No Impact … High Impact	Not effective … Highly effective	Not effective … Highly effective	Not costly … Very costly	Not easy … Very Easy	Not a priority … High priority
ıfamiliar with ffic laws and gulations	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ıfamiliar with hicle systems	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ıfamiliar with road stems	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ck of driver ucation	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ck of safety ucation	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
nguage barriers	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
ıltural differences	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5

Special Population: International Tourists

Issues/concerns affecting the safety of international tourists	1. In your opinion, what impact do these issues have on crash/accident rate? (Check one)	2. In your opinion, how effective would it be to use roadway design changes to address each of these issues? (Check one)	3. In your opinion, how effective would it be to use policy changes to address each of these issues? (Check one)	4. In your opinion, how costly would it be to implement a design or policy change to address each issue? (Check one)	5. In your opinion, how easy would it be to implement the change? (Check one)	6. In your opinion, how much of a priority is it to address each issue/concern? (Check one)
	No Impact … High Impact	Not effective … Highly effective	Not effective … Highly effective	Not costly … Very costly	Not easy … Very Easy	Not a priority … High priority
Unfamiliar with roadway system	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Unfamiliar with driving system	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Difficulty recognizing and understanding traffic signs	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Lack of information about driving laws and customs in US	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5
Confusion in translating English into metric distance on signs	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5	☐1 ☐2 ☐3 ☐4 ☐5