Measuring the Effectiveness of Traffic Control Devices: An Assessment of Driver Understanding

by

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for the

Traffic Safety Section (D-18)
State Department of Highways
and Public Transportation

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DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State Department of Highways and Public Transportation or the U.S. Department of Transportation. This report does not constitute a standard, a specification, or a regulation.

EXECUTIVE SUMMARY

This report summarizes the results of testing situations designed to assess: (1) drivers' knowledge of specific traffic controls; (2) preferred or appropriate driving maneuvers elicited by commonly used traffic controls; and (3) knowledge of standards regarding colors, shapes, and symbols surrounding the traffic communications system. In addition, an attempt was made to determine the severity of hazards posed by misunderstanding certain traffic controls through the use of a Delphi panel. These data from driver surveys and the traffic professionals were used to evaluate the need for driver information and to recommend educational strategies for targeted traffic control devices. Recommended countermeasures in some cases consisted of altering the use of or discouraging use of specific signs and signal combinations.

LEVEL OF DRIVER UNDERSTANDING

The use of four survey approaches to measure motorists' recognition and understanding of 63 traffic controls resulted in detailed findings regarding the three levels of understanding outlined above. The first of these levels, understanding the meaning or inferred standard of a specific control device apart from environmental cues, was measured both in the laboratory and in the field. A small, representative sample of Texas drivers (94) identified traffic controls presented on slides in one phase of an in-depth interview. 372 drivers in selected driver

licensing stations in Texas also identified traffic controls apart from environmental cues as they were presented in questionnaire booklets.

The second level of understanding is a perceptual differentiation of devices based on familiarity with a system of coding - color, shape, symbol, or common usage coding. Familiarity with the shape and color system of coding was determined in the laboratory test.

A third level of understanding is one which takes into account the interaction effects of other communications, including environmental cues, the driving task, and familiarity with the traffic environment. This type of understanding was assessed in the real-time, actual situation format of a film. Table A provides a summary of correct responses for all of the traffic controls examined for each type of assessment.

In providing an overview of Table A with respect to level of understanding of the 63 traffic control devices examined in this study, the following general statements can be made:

- There is a lack of knowledge of the meaning of shapes and colors of signs.
- A significant number of drivers are unfamiliar with basic principles of the road marking system.
- Regulatory signs are the most effectively detected, read, and understood, relative to other signs. They have the highest signal values. However, the importance of wording on verbal messages and conspicuity of signs should be recognized.
- Less than 80 percent of the drivers were certain of the meaning of one-half the warning symbol signs.
- Many drivers are confused by traffic control complexity exhibited in signal displays- arrow/circular combinations, flashing indications, and lane-use control signals.

Table A. Percent Correct Interpretations of Traffic Control Devices by Survey Type.

TRAFFIC CONTROL DEVICE	SURVEY TYPE - PERCENT CORRECT RESPONSE				
	SHAPE	COLOR	SLIDE	FILM	STATEWIDE QUESTIONNAIRE
PAVEMENT MARKINGS					
1. Broken Yellow Center Marking			86- two-way 85- passing	53	87- two-way 87- passing
2. Broken White Center Marking			47- one-way 92- passing	19	46- one-way 92- passing
3. Double Solid Yellow Center Marking			88- two-way 90- no passing	43	92- two-way 95- no passing
4. Broken and Solid Yellow Line Combinations			93- two-way 69- passing	70	93- two-way 65- passing
5. Solid White Line			66- one-way 49- no passing	65	56- one-way 38- no passing
6. Two-Way Left Turn Striping			56		59
7. Two-Way Left Turn Lane Pavement Markings				93	
8. Pedestrian Crosswalk Lines			75		
REGULATORY SIGNS					
9. Stop	56	87			78
10. Yield	40	25			83
11. Do Not Enter					45
12. Speed Limit	87	82		95	
13. Prohibitory Right Turn	53	43	64	68	89
14. One-Way Traffic			48		72
15. Keep Right	52	31	39		67
16. Do Not Pass	76	60			
17. Double Turn	81	58	70	81	53
18. Two-Way Left Turn Only	49	41	60	74	20
19. Climbing Lane Ahead			60		80
20. Yield To Traffic in Center Lane			13		
WARNING SIGNS					
21. Two-Way Traffic	14	43	79		98
22. Turn	18	53	82	80	62
23. Curve			75		95
24. Cross Road					92
25. Stop Sign Ahead			30		42
26. Signal Ahead					94
27. Merge			63	83	76
28. Pavement Width Transition			55	46	68
29. Divided Highway			65		
30. Deer Crossing	39	71	96		
31. Truck Crossing	29	50		95	
32. Fire Station	20	41	70	74	42
33. Pedestrian Crossing	21	74	81	86	86
34. School Advance			24	31	21

Percent Correct Interpretations of Traffic Control Devices by Survey Type (continued)

TRAFFIC CONTROL DEVICE	SURVEY TYPE - PERCENT CORRECT RESPONSE				
	SHAPE	COLOR	SLIDE	FILM	STATEWIDE QUESTIONNAIRE
35. School Crossing	5	76	46	44	50
36. Slippery When Wet	38	71	54	74	81
37. Exit Speed Limit	81	30		24	
38. Pavement Ends			75		
39. Soft Shoulder			85		
40. Large Arrow					18
41. No Passing Zone	1	42		81	27
42. Railroad Advance	58	40	2	33	17
43. Chevron Alignment			37	62	23
CONSTRUCTION SIGNS					
44. Advance Flagger	23	24	53	64	62
45. Low Shoulder			6		63
46. Advance Road Construction	24	42		100	
47. Detour Arrow					53
BARRIERS and DELINEATORS					
48. *Type III Object Marker			20	41	44
49. *Type VI Object Marker					20
50. *Type III Barricade			2		1
SERVICE, INFORMATION, and GUIDE SIGNS					
51. Next Exit Supplmental Sign	77	60			
52. Hiking Trail			21		
53. Hospital	70	35	69	90	86
54. Travel Trail Marker			12		
55. Recreational Interest Area	0	12			
SIGNALS					
56. Yellow Beacon/Flashing Mode				98	54
57. Red Beacon/Flashing Mode					87
58. Red "X" Lane Use Control				50	
59. Green "↓" Lane Use Control				55	
60. Circular Green/Green Arrow			98		
61. Circular Red/Green Arrow				55	59
62. Circular Red/Yellow Arrow			17		18
63. Dont Walk/Flashing mode			10		65

*Discussion not incuded in report; details of analysis are available.

RECOMMENDATIONS

The survey results presented in this report document the existence among Texas drivers of confusion, misunderstanding, or lack of familiarity with certain traffic control devices. Consequences of drivers' conceptual limitations vary according to traffic control device. For example, if five percent of the driving public incorrectly identify the PROHIBITED RIGHT TURN symbol sign, the accident potential is much greater than if 95 percent of the state's drivers are unable to identify the Texas Travel Trail marker. Although measures could be suggested for improving the effectiveness of all traffic control devices, a criticality ranking technique was deployed to recommend target traffic controls for countermeasure approaches.

The traffic controls which were commonly misunderstood and that were considered most critical by a panel of knowledgeable traffic professionals are presented in Table B. This table provides a list of traffic controls identified as most critical that were misinterpreted by at least 10 percent of respondents in the starred cases and by greater than 20 percent for the remainder of the cases listed. The recommended countermeasures listed are based on the primary form of misunderstanding or confusion associated with each sign.

Four types of recommendations and countermeasures for improving the effectiveness of misunderstood traffic controls are outlined below.

I. CONFIRMATION OF EXISTING STANDARDS AND SPECIFIED APPLICATIONS

Some signing and traffic control practices are effective enough as

Table B.

Targeted Traffic Control Devices by Mean Criticality Rank, Primary Misconception and Recommended Countermeasures

Traffic Control Device	Mean Criticality Rank	Primary Form of Misunderstanding	Recommendations and Countermeasures
Regulatory Signs 1. Do Not Enter Symbol Sign (no verbal message)	4.83	65% unfamiliar with symbol meaning. Large "don't know" response - 34%, typically by those without driver education training.	Do not delete verbal message. Implement educational campaign aimed at segment without driver education training.
2. Stop Sign (no verbal message)	4.83	Recognized by less than 80% of drivers by shape and color; the word 'STOP' must be visible to be identified.	Confirmation of standards as applied.
3. YIELD (no verbal message)	4.43	Recall of physical appearance very low. Recognized by less than 90% by shape and color.	Confirmation of standards as applied. Need to educate public to recognize at a distance.
4. One-Way Traffic (no verbal message)	4.30	Confusion primarily with DETOUR arrow sign. Lack of awareness of white/black regulatory color code.	Confirmation of standards as applied. Inform drivers of color code for regulatory versus warning versus construction signs.
5. Prohibited Right Turn	3.91	Prohibitory meaning of red slashed circle understood by less than 70% of drivers. 7% interpreted mandatory right turn rather than prohibitory.	Accompany sign with educational plaque. Implement educational campaign for young, old, and female drivers.
6. Keep Right	3.61	Confused with DIVIDED HIGHWAY symbol sign.	Accompany sign with educational plaque.
7. Yield to Traffic in Center Lane	3.56	Drivers understand to give center lane right-of-way but do not know the context in which this sign is used.	Discontinue Use.
8. Double Turn Symbol	3.35	Difficulty in defining rules for each lane.	Supplement with advance verbal message defining lane use.
Warning Signs 9. Large Arrow (sharp turn)	4.17	Confusion primarily with DETOUR arrow sign. Lack of awareness of yellow warning indication.	Inform drivers of color code for regulatory versus warning versus construction signs.

Table B - continued.

10. No Passing Zone Pennant	4.04	Drivers totally unfamiliar with unique shape. Unfamiliar with symbol meaning. Large "don't know" response - 43%.	Implement educational campaign to increase driver awareness of this sign and its shape and color meaning.
11. Right/Left Turn	3.91	Severity not recognized. Right/Left TURN sign confused with right/left CURVE sign.	Accompany all TURN signs with advisory speed plates.
12. School Crossing	3.74	Not recognized as a school traffic control. Confused with PEDESTRIAN CROSSING.	Educate public on school area verus general warning signs. Accompany sign with educational plaque.
13. Chevron Alignment	3.48	General lack of comprehension of sign meaning. 50% - "don't know" response. Interpreted as a lane change command.	Establish warrants for use. Research use of double-faced chevrons.
Construction Signs 14. Detour Arrow (no verbal message)	3.43	Confusion primarily with ONE-WAY TRAFFIC arrow. Lack of awareness of orange construction code.	Inform drivers of color code for regulatory versus warning versus construction signs.
Pavement Markings 15. Double Solid Yellow Center Marking	4.52	Unfamiliar with two-way characteristic of yellow markings. Do not understand they may be crossed to turn left.	Educate public on white versus yellow pavement markings for directional information and on ability to cross for left turns.
16. Broken Yellow Center Marking	3.96	Unaware that yellow means two-way traffic.	Educate public on white versus yellow pavement markings for directional information.
17. Two-Way (Dual) Left Turn Lane Striping	3.57	Consider the lane for emergency stopping or as a passing lane.	Use Two-way Left Turn arrow pavement markings; mandate arrows placed at high volume turn locations.
Signals 18. Red Beacon (flashing)	4.52	Flashing mode dilutes the command. Only a rolling stop or a check for clearance necessary according to 11%.	Convey to public the requirement to STOP at all red signals. Educate public on difference between yellow and red flashing beacons.
19. Pedestrian "Don't Walk" (flashing mode)	3.65	Pedestrians who have left the curb do not realize the flashing phase allows them time to cross. They consider themselves walking against the light.	Allow ample time to cross during clearance phase.

they are used currently, but the study shows that changes whould have detrimental effects. For instance, the STOP sign, YIELD sign, DO NOT ENTER sign, DETOUR and ONE-WAY TRAFFIC arrow signs should continue to have a written message on them. The evidence shows that a significant portion of the driving population would either misinterpret or disregard these signs as symbols alone.

II. NECESSITY FOR SUPPLEMENTAL INFORMATION ASSOCIATED WITH DESIGNATED TRAFFIC CONTROL DEVICES

Educational plaques are currently necessary for understanding symbol signs such as SCHOOL CROSSING, NO RIGHT TURN, SLIPPERY WHEN WET, and the ADVANCE FLAGGER sign. Motorists also need information or on-site instruction for the meaning of LANE-USE CONTROL sign indications, the safe speed at which to negotiate severe turns, and signs that define directions of travel in addition to pavement markings.

III. REVISIONS OF CURRENT APPLICATIONS RELATIVE TO SPECIFIC CONTROL DEVICES

Upon re-evaluation, it is recommended that some aspects of the communication system of traffic controls need to be changed. This includes development of alternative controls to replace ineffective ones. In some cases, deletion of one control in favor of another control in existence that is more effective and lessens driver overload is warranted. For example, the CLIMBING LANE AHEAD should be deleted and the SLOWER TRAFFIC KEEP RIGHT sign used singularly to convey the intended message.

IV. RECOMMENDATIONS FOR PUBLIC INFORMATION AND EDUCATION EFFORTS

One of the most effective ways to enhance the roadway communication system is to educate those to whom the communication is directed. Driver education and driver improvement programs are positive predictors of knowledge of traffic controls. Attention should be given in these programs to the pavement marking code, the shape and color code, the meaning of symbol signs, and correct responses to the more complex traffic signal indications.

These efforts should also be directed at the driving public at large. Information can be transmitted in Department of Public Safety driver licensing stations. Public service announcements and educational campaigns are other strategies that can be used to educate the public at large. These approaches may also be quite effective in reaching "targeted" groups who have specific information needs.

Among the many controls warranting educational countermeasures, the following are particularly critical: DO NOT ENTER symbol sign; color code distinctions among ONE-WAY TRAFFIC, LARGE ARROW (Sharp turn), and DETOUR arrow signs; PROHIBITED RIGHT TURN; crossing (on-site) versus advance signs, such as SCHOOL CROSSING and SCHOOL ADVANCE; and the directional aspects of pavement markings.

OVERVIEW

As the number of vehicles on roadways has increased, a need has developed for more precise traffic information, including a set of standards to encourage safe driving practices. The communication of

standards regarding speed, boundaries of operation, direction of travel, and warnings of possible hazards has greatly complicated the process of providing driver information. The purpose of this study has been twofold:

- To determine, based on misinterpretation, confusion, or unfamiliarity, the traffic information needs that exist for Texas motorists, and
- To assist the State Department of Highways and Public Transportation in providing educational and other strategies that will diminish the number of accidents caused by a lack of driver information.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. FACTORS INFLUENCING THE EFFECTIVENESS OF THE TRAFFIC COMMUNICATION SYSTEM

Since the emergence of automobiles the need for effective roadway communication with the driver has rapidly increased. To maintain a vehicle in its intended path, the driver must have information about the path, such as its borders and geometry. As the number of motor vehicles on the road has increased, a need has developed for more precise information, including a set of regulations prohibiting unsafe driving practices. The communication of these restrictions on speed, boundaries of operation, and direction of travel have complicated the process of driver communication. Also, the addition of warnings to advise drivers about possibly hazardous conditions have further increased demands in the already loaded communication system.

The increasing complexity of traffic systems has required the use of numerous colors, shapes, symbols, and verbal messages to advise the driver about the road ahead. Engineers and researchers have made great efforts to simplify the traffic control system to provide for greatest public understanding. But even under optimal conditions, the current traffic communication devices are complex in meaning and frequently misunderstood by drivers. In addition, extraneous environmental factors, such as the proliferation of commercial billboards, signs, and flashing lights have further debilitated the effectiveness of the transportation communications provided.

All these factors combined increase the probability that the driver will encounter more information than he or she can process. This possibility of "information overload", as well as widespread misunderstanding

of individual control devices suggests the need for a re-evaluation of the driver requirements for the traffic communication system.

This report summarizes the results of four testing situations designed to assess: (1) drivers' perceptions of meanings of commonly used traffic controls; (2) correct identification of specific controls; (3) knowledge of standards regarding shapes, colors and symbols; and (4) the severity of hazards posed by misunderstanding traffic control devices. These data were used to evaluate the need for driver information and educational efforts and to assess the need to discourage use of or delete certain traffic controls.

Roadway communication devices are designed to provide drivers with sufficient information to reach destinations efficiently and safely. Figure 1 outlines the factors influencing the effectiveness of the traffic control system. Factors above the central, horizontal line reflect physical aspects of the communication system. Variables described below the horizontal bar encompass socio-psychological factors affecting the successful utilization of traffic control devices. In Figure 1 three major dimensions are evaluated--detection, reception ("reading" of the traffic control), and understanding. A fourth and final dimension, that of utilization of the communication, is discussed in a forthcoming section.

DETECTION OF TRAFFIC CONTROLS

One area of human factor requirements that has been extensively examined is that of visibility. Research in this area has dealt with two major components of visibility: conspicuity and legibility. Con-

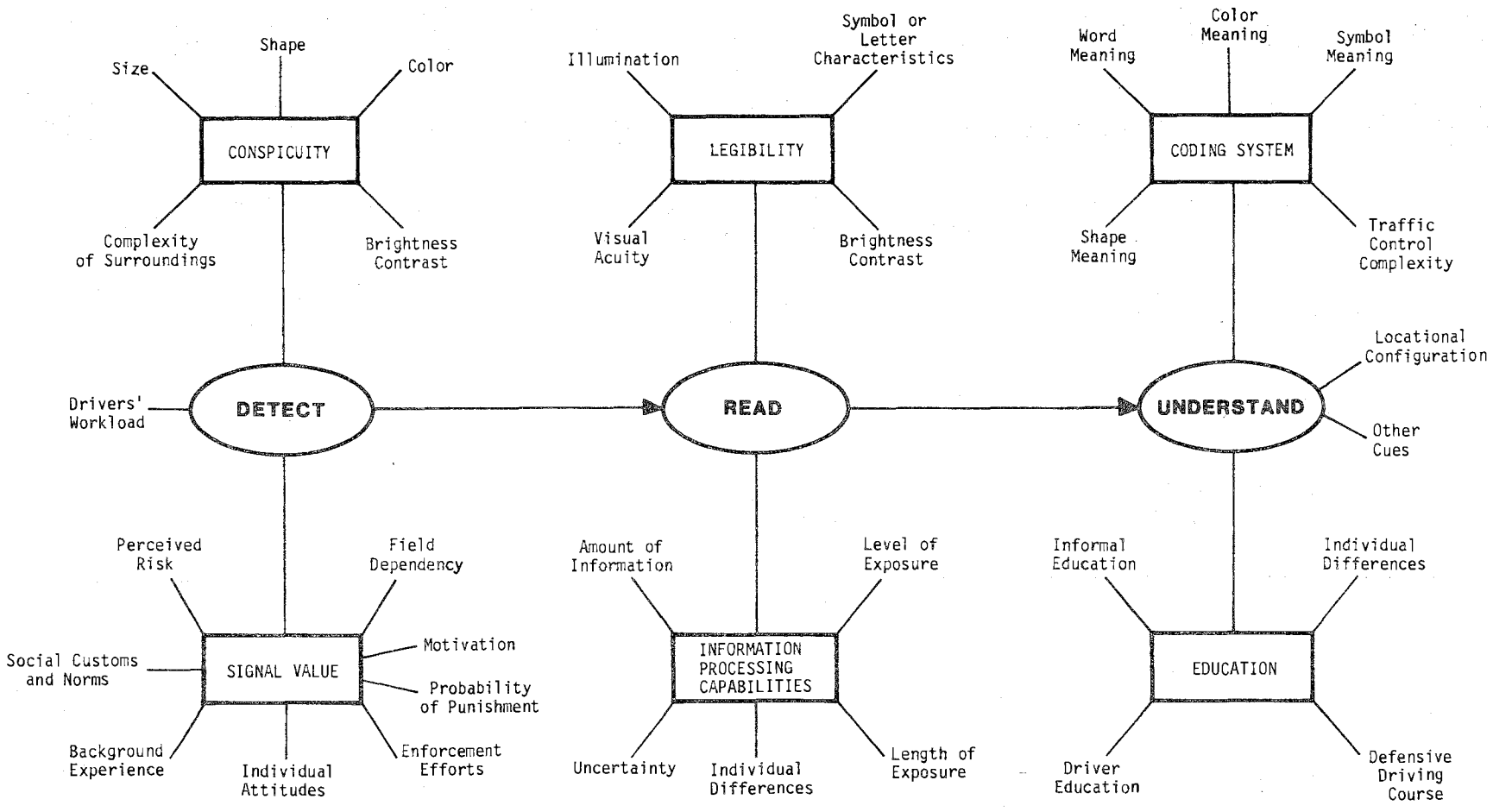


FIGURE 1. Factors Influencing the Effectiveness of Traffic Control Devices

spicuity refers to the probability that a sign, pavement marking, or other traffic control will be detected, based on the physical configuration of the communication device (see the upper left side of Figure 1). When the number of controls increases in any given visual space, the probability that any one of the communication devices will be detected is decreased.

The effectiveness of a traffic control to a large extent depends on conspicuity as determined by brightness contrast, primarily the similarity of the control device relative to its surroundings. Other important factors affecting conspicuity are the shapes, sizes, and colors of the traffic controls.

An increasing complexity of the driver communication system suggests the need for re-evaluating the driver's informational load. Information overload is a well documented phenomenon which results when the amount of information exceeds the processing capacity of the driver. Any additional information given the driver at this point will result in a loss of that or other information. Ferrell (1971) reports that the most common reaction is not to respond at all to traffic controls. This non-response is demonstrated by slowing down, or making incorrect driving manuevers, thus causing congestion, safety problems, and increased fuel consumption.

Hakkinen (1965) examined the factors that determine signal value, the basis on which signs, markings, and other traffic controls are selectively detected or eliminated. Three factors are reported to affect the signal role of a traffic control device. The first is the driver's perceived risk for himself, other passengers, or other road

users in a given situation. This perceived risk is dependent upon the driver's experience, education, and the specific traffic control under consideration. The probability of seeing a traffic sign or pavement marking is lessened with increased experience in driving, and each type of sign has a specific rate of decline. The rate of decline for various traffic controls represents a sort of internal risk or internalized criticality measure. One of the purposes of the present research is to assess the differences between these internal criticality values.

Secondly, signal value is determined by the probability of punishment for disobedience of the traffic control. Speed limit signs have been found to have a high signal value, which is a result of the motorist's awareness of constant enforcement efforts. Other signs which are less frequently enforced would be expected to have a lower signal value, in spite of the fact that violation of these signs may prove more hazardous.

A third factor influencing the signal value of traffic controls is the customs and norms of certain groups of drivers. Closely tied to this social dimension are individual attitudes. Initially, the signal value is determined by perceived risk and the probability of punishment. With experience, however, customs, norms, and individual evaluations become an important factor in the determination of signal value. Professional drivers with years of experience would be influenced to a greater extent by social norms and attitudes than the newly licensed driver. Also, the influence of these customs change with time, making them difficult to study.

Naatanen and Summala (1976) identified two traits of certain drivers which lead to decreased awareness of road signs. The drivers often are deficient in motivation due to a perceived unimportance of the device. Also, certain individuals have a visual deficit known as field dependence which makes it difficult for them to detect signs (Loo, 1978).

READABILITY OF TRAFFIC CONTROLS

Legibility refers to the driver's ability to read a sign or identify a pavement marking or delineator. Figure 1 portrays the variables influencing legibility of a control device. Legibility is a function of brightness contrast, symbol or letter characteristics, illumination, and the driver's visual acuity. Legibility requirements have been extensively evaluated and have been incorporated into current standards, as evidenced in the Manual on Uniform Traffic Control Devices for Streets and Highways (Federal Highway Administration, 1978).

Information processing capabilities also depend on visual acuity, a physiological trait, and other legibility, conspicuity, and signal value factors. The amount of information received from any one traffic control or from the interaction of several controls is of prime importance in reading. Individual differences emerge in the educational level of the motorist, English-reading capabilities for signs with verbal communications, and previous driving experience.

Information processing capabilities are also dependent on the uncertainty or confusion of the motorist in correctly identifying the communication device. Uncertainty is distinct from incorrect identifica-

tion of the traffic control, as will be discussed further in a later section of the report.

Level of exposure refers to the number of times the driver has read the communication before. Length of exposure refers to the viewing time of the recipient. This latter factor has been extensively examined by McNees and Messer (1980). Both level and length of exposure are salient variables affecting the motorist's information processing capability.

DRIVER UNDERSTANDING OF TRAFFIC CONTROLS

Earlier portions of this chapter dealt with: (1) the perception of a traffic communication device given a certain signal value; and (2) "reading" the traffic control given certain legibility and information processing capabilities. This section will cover the motorist's level of understanding of the sign, pavement marking, or other communication, once it has been read.

The coding system for signs and pavement markings has reached a high level of specificity in the past two decades and standardization has occurred primarily within the past 10 years. Colors, shapes, words, and symbols have precise meanings which are presented to the public through formal education programs. Of additional importance is the complexity of the traffic control. The regulatory sign, YIELD TO TRAFFIC IN CENTER LANE, may be read correctly but the interactive effects of the words misunderstood; for example, there may not be a "center" lane as viewed by the motorist.

Additional psycho-physical aspects affecting the understanding of traffic controls include other cues or clues to correctly identifying the traffic control and the locational configuration of the communication. Cues to understanding the yellow broken lines on an access road include the TWO-WAY traffic signs and actual observation of other vehicles. In daily situations, many motorists simply "ride with the tide" of traffic or stay in the traffic flow, unable to independently navigate the roadway. Locational configuration of the traffic control is also of paramount importance in motorist's understanding the intention of the device. While rigorous standards exist regarding placement, the characteristics of each site affect the level of understanding of the traffic communication.

Education regarding traffic controls, in the form of driver education, defensive driving, and informal education, has a direct effect on correct identification of these devices. One of the purposes of this study is to relate these educational efforts to level of understanding of traffic communication systems.

The understanding of specific devices has been found to be a function of education level, driving experience, driver education, age, and a number of other factors. Two recent studies have evaluated the level of understanding in the general public and examined the demographic variables which are related to these deficits.

Hulbert, et al. (1979) surveyed 3164 motorists in all areas of the country to determine their understanding of 16 traffic control devices. The driver's understanding varied from 18 percent for one device to 97 percent for another device. Hulbert, et al. found that the drivers

understood symbol signs better than either signals or pavement markings. They report 18 percent knowledge of the SCHOOL ZONE SIGN and 45 percent of the SCHOOL CROSSING SIGN. Additionally, the common problem with the meaning of "orange" indicating highway construction was observed.

In another study, Koppa, et al. (1978) surveyed the public understanding of traffic control devices in Texas. This study evaluated 27 traffic control devices, and resulted in a list of eleven of the most seriously misunderstood traffic control devices. The specific population segments that should be the targets of educational efforts were: (1) those with low driving exposure; (2) the old and young drivers and (3) ethnic minorities with language and other barriers to understanding.

Throughout the discussion of correct identification of traffic controls, three levels of analysis emerge:

1. Understanding the meaning or inferred standard of a specific traffic control device apart from environmental cues.

2. Understanding a system of coding - color, shape, symbol, or common usage coding.

3. Understanding a specific traffic control given the interaction effects of other communications, heavy driver workload, or extensive over-familiarity with the environment.

The first of these levels, understanding a specific communication, is dependent on the information provided the driver and the way this information has been assimilated.

The second level of understanding, that of using a system of coding is much more difficult. The driver may see the sign of a school crossing and understand the meaning without comprehensive knowledge of

the color code. However, these coding systems are subconsciously reinforcing. For instance, a yellow sign which is a warning, is repeatedly seen in a dangerous situation, thus building this association. Other signs yellow in color could elicit a somewhat subconscious association that danger is present. These cues of color and shape may not be consciously known to the drivers, but could possibly have an effect on the driver, because of previous associations with danger. Therefore this lack of understanding may not indicate that the sign has no value.

The third level of understanding relates to the driver detecting and correctly identifying the sign given either: (1) cues from other similar traffic controls; (2) heavy information load; or (3) over-familiarity with the driving environment. In the first instance, that of redundent cues, a traffic sign may typically be placed so that the roadway itself or pavement markings explain the meaning of the sign. In this case, understanding the sign is a relatively simple task.

With an information overload, the driver is faced with the decision to attend to all of the information available, including billboards and other vehicles, and normally slows down in order to do so. Or the motorist may reject, or not attend to, some of the information. In so doing, the driver may not correctly identify any alterations in the driving environment.

In a third situation, a high level of exposure on a specific roadway may cause drivers to overlook all traffic controls with no ability to recall the signs or markings that they have seen. The roadway can be negotiated without actually using the communication devices present.

II. TECHNIQUES USED IN DRIVER KNOWLEDGE DIAGNOSTIC TESTS

Four different testing situations were used to determine level of understanding of commonly used traffic controls:

1. Shape and color identification test in laboratory -- used to determine drivers' knowledge regarding color and shape coding for 25 traffic signs (see Table 1, Column II).

2. Traffic controls slide identification test in laboratory -- used to assess drivers' ability to name and provide the interpretation for the use of 40 signs, markings, delineators, signals, and barricades, as shown in Table 1, Column III.

3. Driver response test in laboratory -- used to ascertain drivers' stated reactions to 32 filmed driving situations in real time format (see Table 1, Column IV).

4. Field test of correct meanings attributed to 46 traffic control devices using a random sample of drivers in Department of Public Safety licensing offices (see Table 1, Column V).

IN-DEPTH INTERVIEWS

The first three tests were undertaken as in-depth interviews with 94 repondents. A quota sample was used to obtain respondents representative of Texas' driving population. A preferred, rigorously representative quota is delineated in Figure 2. The sample was stratified by age, ethnicity, and sex, as these three background characteristics had proved to be significant predictors of driver understanding in the Koppa, et al. (1978) study. Figure 3 depicts the actual sample of 94 respondents interviewed. The sample was localized; subjects were residents of the Bryan-College Station metropolitan area. As shown by comparison of Figures 2 and 3, the sample underrepresents primarily the older age cohort. Otherwise, the actual and preferred quota samples are closely comparable.

Table 1. Traffic Control Devices Included in Testing Situations

	I Mandated Assessment (Contract)	II Shape & Color Test (self-administered)	III TCD Identification Test (slides)	IV Driver Response Test (8mm film)	V Driver License Station Test
PAVEMENT MARKINGS					
1. Broken Yellow Center Marking	X		X		X
2. Broken White Center Marking	X		X	X	X
3. Double Solid Yellow Center Marking	X			X	X
4. Broken and Solid Yellow Line Combinations	X		X	X	X
5. Solid White Line	X		X	X	X
6. Two-Way Left Turn Striping			X	X	X
7. Two-Way Left Turn Lane Pavement Markings				X	
8. Pedestrian Crosswalk Lines			X		
REGULATORY SIGNS					
9. Stop		X			X
10. Yield		X			X
11. Do Not Enter					X
12. Speed Limit		X			
13. Prohibitory Right Turn	X	X	X	X	X
14. One-Way Traffic			X		X
15. Keep Right		X	X		X
16. Do Not Pass			X		
17. Double Turn		X	X	X	X
18. Two-Way Left Turn Only		X	X		X
19. Climbing Lane Ahead			X		X
20. Yield To Traffic in Center Lane			X		

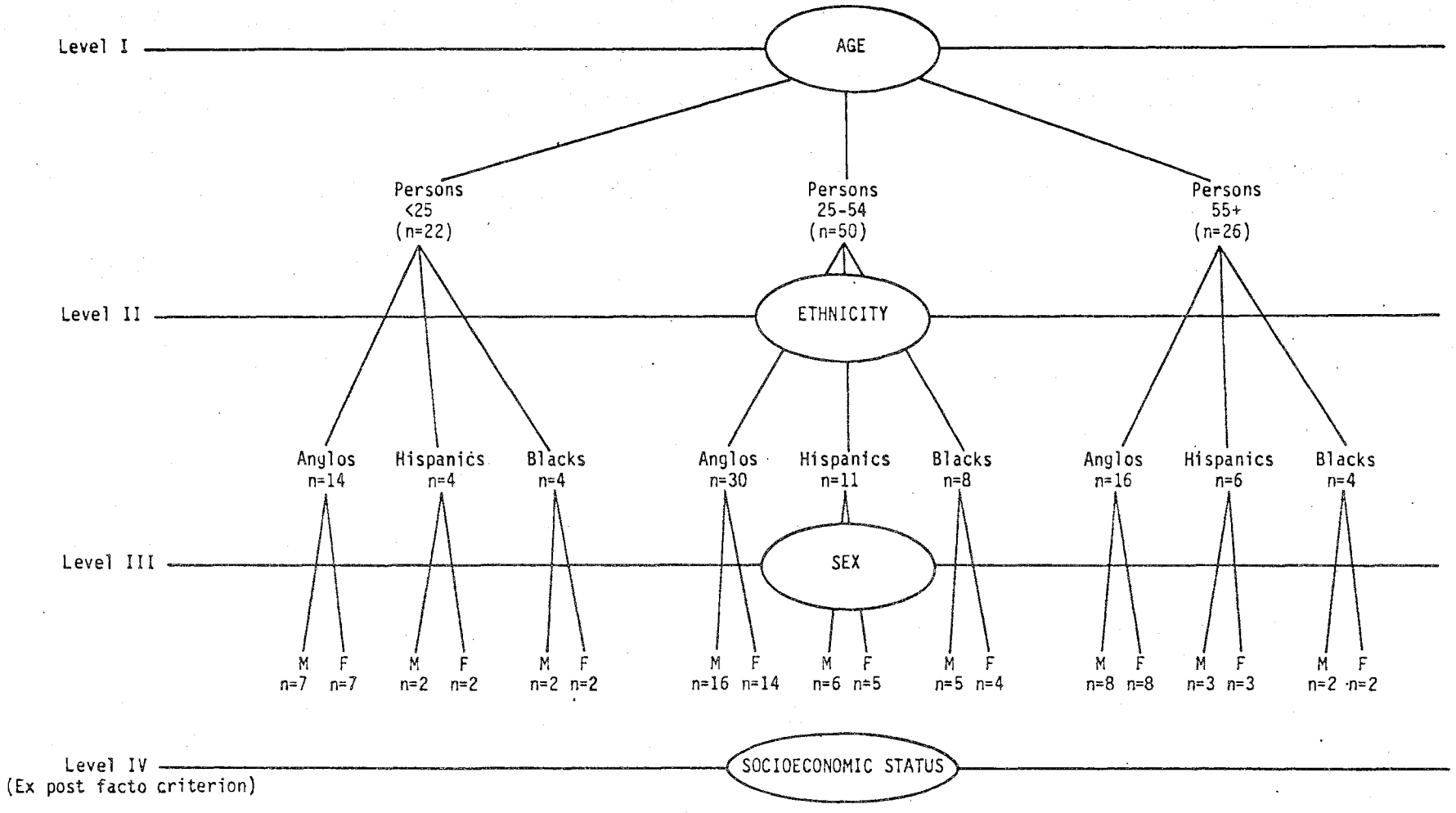
Table 1. Traffic Control Devices Included in Testing Situations (continued)

	I Mandated Assessment (Contract)	II Shape & Color Test (self-administered)	III TCD Identification Test (slides)	IV Driver Response Test (8mm film)	V Driver License Station Test
WARNING SIGNS					
21. Two-Way Traffic	X	X	X	X	X
22. Turn					
23. Curve					
24. Cross Road					X
25. Stop Sign Ahead			X		X
26. Signal Ahead					X
27. Merge			X	X	X
28. Pavement Width Transition		X	X	X	X
29. Divided Highway			X		X
30. Deer Crossing		X	X		
31. Truck Crossing		X		X	
32. Fire Station		X	X	X	X
33. Pedestrian Crossing		X	X	X	X
34. School Advance	X		X	X	X
35. School Crossing		X	X	X	X
36. Slippery When Wet		X	X	X	X
37. Exit Speed Limit	X	X		X	
38. Pavement Ends			X		
39. Soft Shoulder			X		
40. Large Arrow					X
41. No Passing Zone		X		X	X
42. Railroad Advance		X	X	X	X
43. Chevron Alignment			X	X	X

Table 1. Traffic Control Devices Included in Testing Situations (continued)

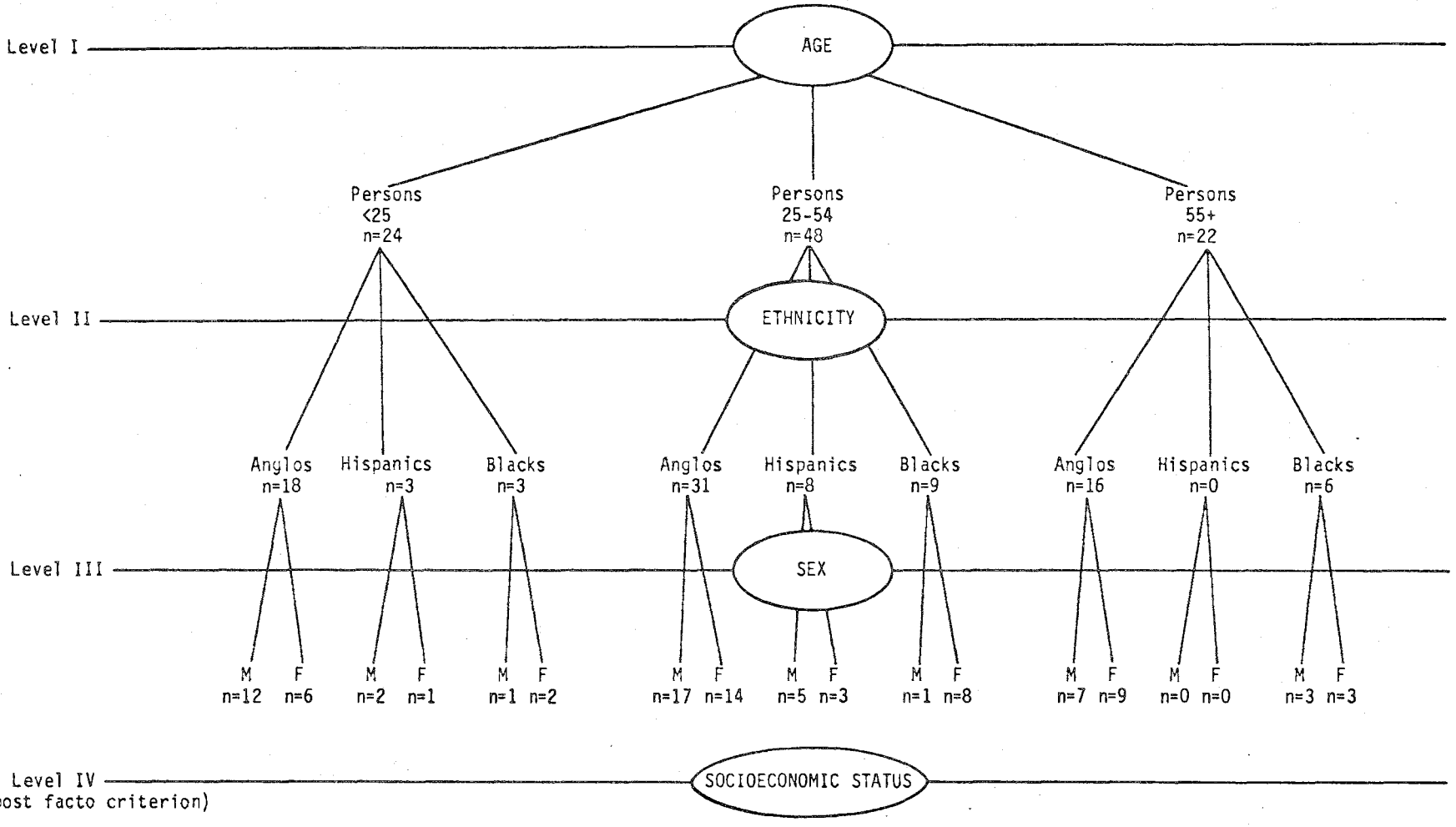
	I Mandated Assessment (Contract)	II Shape & Color Test (self-administered)	III TCD Identification Test (slides)	IV Driver Response Test (8mm film)	V Driver License Station Test
CONSTRUCTION SIGNS					
44. Advance Flagger	X	X	X	X	X
45. Low Shoulder			X		X
46. Advance Road Construction	X	X		X	
47. Detour Arrow					X
BARRIERS and DELINEATORS					
48. Type III Object Marker			X	X	X
49. Type VI Object Marker					X
50. Type III Barricade			X	X	X
SERVICE, INFORMATION, and GUIDE SIGNS					
51. Next Exit Supplemental Sign		X			
52. Hiking Trail			X		
53. Hospital		X	X	X	X
54. Travel Trail Marker			X	X	
55. Recreational Interest Area		X			
SIGNALS					
56. Yellow Beacon/Flashing Mode				X	X
57. Red Beacon/Flashing Mode					X
58. Red "X" Lane Use Control				X	
59. Green "↓" Lane Use Control				X	
60. Circular Green/Green Arrow			X		
61. Circular Red/Green Arrow				X	X
62. Circular Red/Yellow Arrow			X		X
63. Dont Walk/Flashing mode			X		X

Figure 2. Quota Sample For In-Depth Interviews (n = 98)



Blue Collar unskilled workers	n = 12
Blue Collar skilled workers	n = 15
White Collar workers	n = 27
Unemployed (housewives, students, retired, and temporarily unemployed)	n = 44

Figure 3. Actual Sample for In-Depth Interviews
(overall n=94)



Blue Collar unskilled workers	n = 17
Blue Collar skilled workers	n = 6
White Collar workers	n = 26
Unemployed (housewives, students, retired, and temporarily unemployed)	n = 45

Respondents were originally contacted through the Texas A&M physical plant, university classes, a senior citizens group, two local churches, a Mexican-American voluntary organization, and notices at laundromats and other similar locations. The scheduling of the in-depth interview was by telephone. At this time the respondent was given general information about the purpose of the interview, the amount of time involved, and the way in which the respondent would be paid. Students were paid $5.00 for participation and all others $7.00 for involvement in the study. Average duration of the interviews was 1.25 hours.

FIELD TESTING

Through in-depth interviews, common incorrect interpretations for specific traffic controls were determined. From this data, a structured survey instrument was developed for use at selected driver license stations. This field test was undertaken through a cooperative arrangement with the Texas Department of Public Safety at nine stations in six localities in Texas. The metropolitan areas of Houston, Dallas, El Paso, and McAllen/ Pharr were included in the sampling procedure, as well as two rural areas-- Anderson and Terry Counties. The counties or metropolitan areas selected were, in the aggregate, representative of the state overall. A quota sample was developed for the six locations, so that the respondents obtained at the stations would represent the composition of the Texas driving population (see Table 2). The actual sample, drawn from the six regions of the state, is described in Table 3.

Table 2.
Quota Sample for Field Test
(Quotas and Percentages for Each Population Segment)[a]

n = 372

Driver Segment	County or Standard Metropolitan Statistical Area											
	Houston SMSA n=172		Dallas SMSA n=123		El Paso SMSA n=37		McAllen/Pharr/ Edinburg SMSA n=17		Anderson County (Palestine) n=13		Terry County (Brownfield) n=10	
Sex												
Males	93	(54)	64	(52)	21	(56)	10	(59)	7	(57)	6	(57)
Females	79	(46)	59	(48)	16	(44)	7	(41)	6	(43)	4	(43)
		100%		100%		100%		100%		100%		100%
Age												
<25	37	(22)	26	(21)	9	(24)	4	(25)	3	(23)	2	(17)
25-54	107	(62)	72	(59)	22	(59)	10	(56)	6	(47)	6	(59)
55 +	28	(16)	25	(20)	6	(17)	3	(19)	4	(30)	2	(24)
		100%		100%		100%		100%		100%		100%
Ethnicity												
Anglo	118	(69)	95	(77)	15	(40)	3	(19)	10	(73)	7	(72)
Black	35	(20)[b]	21	(17)[c]	1	(3)[d]	1	(2)[e]	3	(25)[f]	1	(4)[g]
Hispanic	19	(11)[h]	7	(6)[h]	21	(57)[h]	13	(79)[h]	0	(2)[h]	2or3	(24)[h]

a All proportions are based on Dec. 1979 driver license quotas per population segment, obtained from a TTI driver sample of 75,000 drivers.

b 20 percent (1970 Census); 13 percent (driver license sample)

c 17 percent (1970 Census); 10 percent (driver license sample)

d 3 percent (1970 Census); 3 percent (driver license sample)

e 2 percent (1970 Census); 2 percent (driver license sample)

f 25 percent (1970 Census); 25 percent (driver license sample)

g 4 percent (1970 Census); 4 percent (driver license sample)

h All Hispanic percentages based on 1970 Census.

Table 3.
Actual Driver Sample for Field Test

n = 375

Driver Segment	County or Standard Metropolitan Statistical Area					
	Houston SMSA n=175	Dallas SMSA n=123	El Paso SMSA n=37	McAllen/Pharr/ Edinburg SMSA n=17	Anderson County (Palestine) n=13	Terry County (Brownfield) n=10
Sex						
Males	104 (59)	64 (52)	21 (56)	8 (47)	6 (43)	6 (57)
Females	71 (41)	59 (48)	16 (44)	9 (53)	7 (57)	4 (43)
Age						
<25	54 (31)	27 (22)	9 (24)	9 (53)	5 (38)	2 (20)
25-54	101 (58)	75 (61)	23 (62)	6 (35)	5 (38)	6 (60)
55 +	20 (11)	21 (17)	5 (14)	2 (12)	3 (23)	2 (20)
Ethnicity						
Anglo	106 (60)	96 (78)	15 (40)	5 (29)	9 (69)	7 (70)
Black	28 (16)	17 (14)	0 (0)	1 (3)	3 (23)	0 (0)
Hispanic	24 (14)	7 (6)	12 (57)	21 (71)	1 (8)	3 (30)
Other	17 (10)	3 (2)	0 (0)	0 (0)	0 (0)	0 (0)

Surveyors at driver license stations were to randomly select respondents, with the quota sample shown in Table 2 used only if the actual sample appeared to be getting highly skewed. The actual driver sample closely represents the preferred quotas by segments. Young (newly licensed) drivers appeared to be over-represented for the McAllen/Pharr/Edinburg SMSA and the Houston SMSA, based on an earlier 1979 sample of Texas drivers by age.

III. DRIVER UNDERSTANDING OF ROAD MARKINGS

The Manual on Uniform Traffic Control Devices (MUTCD) sets forth the standards that govern the design and usage of traffic control devices. In this manual, basic requirements are listed that traffic control devices should meet to be effective. These requirements stipulate that traffic controls should:

- Fulfill a need
- Command attention
- Convey a clear, simple meaning
- Command respect of road users
- Give adequate time for proper response

In order to meet these requirements, there are five factors that must be considered: design, placement, operation, maintenance, and uniformity.

According the the national MUTCD, (1971:4): "uniformity of traffic control devices simplifies the task of the road user because it aids in recognition and understanding. It aids road users, police officers, and traffic courts by giving everyone the same interpretation. However, uniformity in the provision of standards does not necessarily result in uniform interpretations by the driving public. The interpretation of commonly used traffic controls by Texas drivers is the subject of this and the subsequent five chapters.

THE EFFECTIVENESS OF ROAD MARKINGS

This chapter provides an assessment of drivers' understanding of the road marking code. Several studies have been done previously that dealt specifically with drivers' understanding of road markings. One

early study by Taylor and Hubbell (1967) evaluated "understanding" in terms of direction of traffic and safety of passing. In this study, subjects were questioned concerning the road marking system currently in use and the revised system, which was to be adopted. The results of the study showed that drivers were able to give very correct interpretations of the solid yellow and broken white lines. Also, after the new system was explained, subjects were able to understand the meanings of markings exhibited on slides.

In the above study, the contrived situation allowed for explanations of the road marking system, both old and new, to be given. Unfortunately, every driver on the road was not afforded the opportunity to have the road marking system explained on an individual or small group basis when the changes were made. Later studies showed that meanings of pavement markings were often misunderstood by both experienced and novice drivers. A 1976 study of 230 government employees showed that, with the possible exception of double solid yellow lines, markings were not well understood. "Many misconceptions were shown in the explanation of the markings and the percentage of correct answers was low" (Gordon, 1976:16).

The following is a description of Texas respondents' understanding of eight different pavement markings that were presented to them in film, slide, and questionnaire form.[1] A synopsis of the findings for

[1]Refer to Chapter III for more information regarding the in-depth interview and field approaches utilized.

each marking is provided in italics. The summary information is given in terms of structured and unstructured responses. A structured response is one in which respondents are asked to select their answer from among several that are provided by the researcher. An unstructured response is one in which respondents provide their own answers to a question. Because of the many possible responses to an unstructured question, the data provided in the summary represents those answers which are completely correct and those that are completely incorrect interpretations. Some subjects gave responses that revealed a partial knowledge of a road marking and this information is excluded in the italicized summary; therefore, percentages do not total 100.

1. Broken Yellow Center Marking

I. Structured Responses (Slide Survey and Field Survey)

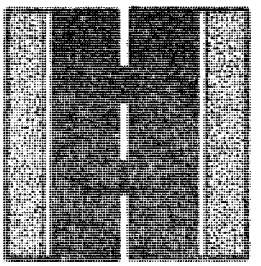
87% - two-way traffic

87% - passing permitted

II. Unstructured Responses (Film Survey)

53% - two-way traffic and passing is permitted

28% - incorrect interpretation of broken yellow center marking



A single broken yellow line is used to separate traffic traveling in opposite directions where passing is permitted. A schematic drawing was presented to 469 drivers who were asked if the road was one-way or two-way and if passing would be permitted. The broken yellow center marking was incorrectly identified by 13 perecent of the respondents as

signifying a one-way street. Futhermore, 13 percent responded that passing was not permitted with this type of striping.

To determine the level of understanding of the yellow broken line in a context more similar to the actual driving situation, 91 respondents were shown film footage taken from the driver's seat of a moving vehicle. They were asked to describe what the broken yellow line meant if they were the driver of the car in the film.

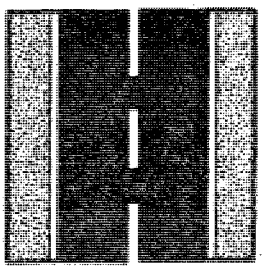
Seventy-two percent of the respondents gave a response that was correct to some degree. Fifty-three percent mentioned that the broken yellow line signified two-way traffic and that passing was permitted. However, 20 percent indicated one or the other, but not both meanings of this marking.

Incorrect answers are those that contradict the MUTCD interpretation. Seven percent of the incorrect answers were identification of the road as one-way. Eight percent were incorrect statements concerning the ability to pass. Of this eight percent, five percent perceived the yellow color as an indication that passing was dangerous, while three percent thought passing was not permitted for this type of marking. This finding is consistent with Gordon's results concerning the broken yellow line. Gordon (1976:23) concluded, "yellow colored markings are associated with hazard, not with the assigned meaning of traffic moving in the opposite direction on the adjacent lane". In this same study Gordon asked drivers their preferences for road lines that are logical and understandable. Although subjects chose markings mainly on the basis of prevailing road markings, they did not support the broken

yellow line for the center of a two-lane, two-way road where passing is permitted.

As mentioned in Chapter I, cues in the environment aid the motorist in correctly identifying traffic controls. Environmental cues are no doubt essential to almost half of the driving public because this study shows that only 53 percent of those tested in real time, real situational format had a complete comprehension of the meaning of the broken yellow pavement marking. Although respondents were more accurate when forced to make a decision among two choices, there was still an important 13 percent that incorrectly identified broken yellow lines as signifying one-way traffic and 13 percent that thought passing would not be permitted. The 13 percent (overall, for all tests) unaware of their ability to pass in this situation may cause themselves some inconvenience, but at least are not likely to cause a serious accident by refraining from passing. However, the 13 percent who are not aware of the counter-directional meaning of yellow pavement markings are strongly reliant upon environmental cues to guide them. Since the likelihood of observing other vehicles on the road is lessened on rural and frontage roads, it is recommended that, especially in these locations, supplemental signs warning of two-way traffic be displayed liberally. In short, it should not be assumed that broken yellow lines will convey two-way traffic to more than 72 percent at worst (according to the film survey responses showing ability to verbalize the meaning of the marking without prompting) or 87 percent at best (according to a structured format where choices are presented) of the driving public.

2. Broken White Center Marking



I. Structured Responses (Slide Survey and Field Survey)
47% - one-way traffic
92% - passing permitted

II. Unstructured Responses (Film Survey)
19% - one-way traffic and passing is permitted
37% - incorrect interpretation of broken white center marking

A broken white line is intended to define lanes of travel where movement on both sides is in the same direction. When asked whether a diagram of a road with a broken white line is one-way or two-way, 47 percent of 469 persons surveyed said one-way and 53 percent said two-way. Furthermore, of the 91 drivers who saw this marking in a driving context by means of a film, only 44.5 percent gave the meaning as a one-way indication. Of the 44.5 percent who recognized the broken white line in a driving context, 19 percent also mentioned that the broken line meant passing was permitted. An additional 12 percent viewing the film described the line as a center line or a division of lanes but made no mention of the uni-flow meaning. Twenty-three percent of those who viewed the film, when asked, "what is the meaning of the white dashed line on this road," responded "two-way traffic."

When given a yes or no choice on whether passing was permitted, 92 percent said yes. In the film approach with no structured response, seven percent of the people questioned regarding meaning of broken white lines mentioned that white lines meant passing was permitted.

That less than half of all those surveyed recognized the broken white line as defining lanes of travel in the same direction may be

partially explained by question sequence. This road marking was the first to appear in the slide presentation and in the survey booklet. Responses to the slides were given verbally, and it was observed that upon seeing the yellow broken lines that followed, some respondents seemed to realize that the two were different. For those who wanted to alter their original answers, it was as if seeing a drawing of a road with a center stripe automatically triggered the two-way response. However, the next slide of a yellow broken stripe cued them to the difference. Respondents to the booklet survey were instructed not to change answers once a page was turned.

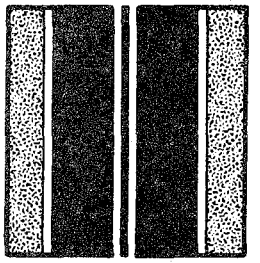
The order was reversed in the film survey. Respondents saw the broken yellow line first, and the broken white line did not immediately follow. With no prompting, 24 percent of the 91 respondents gave answers that were in no way correct regarding the complete meaning of the white broken line. Another 12 percent incorrectly identified the directional meaning but did recognize the permissive character of the broken stripe for passing. The remaining 64 percent were at least partially correct, but only 19 percent had complete comprehension of this marking.

Overall results of the three surveys showed that 83 percent recognized the ability to pass with a broken white center marking. This knowledge is considerably higher than the awareness of white as a directional cue, with only 47 percent overall correctly identifying this feature. Since such information is critical in terms of preventing head-on collisions, it is strongly recommended that one-way directional

arrows be displayed liberally where other environmental cues may be sparse.

It is apparent that the driving public is in need of education on the poorly understood color coding system to indicate directions of traffic. The use of yellow versus white is not apparent to a significant number of drivers.

3. Double Solid Yellow Center Marking



I. Structured Responses (Slide Survey and Field Survey)
- *92% - two-way traffic*
- *94% - passing not permitted*

II. Unstructured Responses (Film Survey)
- *43% - No passing for either direction of traffic*
- *3% - incorrect interpretation of double solid yellow center marking*

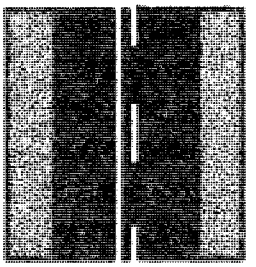
Double solid yellow lines separate counter-directional traffic where overtaking and passing is prohibited in both directions. The restrictions against passing were fairly well understood by most of those surveyed. In the simulated driving situation of the film survey, 97 percent recognized the prohibitive feature of the double solid yellow lines. Ninety-four percent responded correctly on the booklet and slide surveys that the lines in the road diagram do not permit passing.

Respondents were more knowledgeable about the two-way nature of double yellow lines than single yellow broken lines. When given a choice between one-way and two-way, 92 percent of those surveyed answered correctly. However, when asked to give the meaning of the

lines in the film survey, only 43 percent mentioned the directional characteristic.

The knowledge level associated with no passing on double yellow lines may be attributed partially to the emphasis of the restriction by the use of supplemental signs. The DO NOT PASS sign, the NO PASSING ZONE sign, and in Texas the additional explanatory signs such as DO NOT CROSS DOUBLE YELLOW LINE TO PASS are effective reinforcements for the restriction indicated by this pavement marking.

4. Broken and Solid Yellow Line Combinations



I. Structured Responses
93% - two-way traffic
69% - passing permitted in one direction

II. Unstructured Responses (Film Survey)
99% - recognition of passing restriction

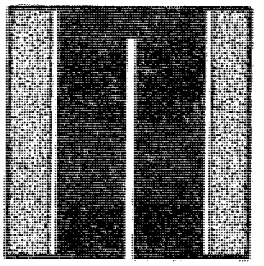
"A double line consisting of a normal broken yellow line and a normal solid yellow line delineates a separation between travel paths in opposite directions where overtaking and passing is permitted with care for traffic adjacent to the broken line and is prohibited for traffic adjacent to the solid line" (MUTCD:3A-3).

With only one exception, all the respondents who were presented with the solid and broken double lines in the film situation recognized the no-passing situation. Seventy percent specified the application to vehicles in one direction.

Responses to the diagram of this marking were not uniform. Only 69 percent of the 469 tested acknowledged the ability for either direction of traffic to pass. Ninety-three percent correctly identified the counter movement indicated by the yellow lines.

In the slide presentation, respondents were first asked if the drawing represented a one-way or a two-way road, then if passing would be permitted, and if so, for which lane. Twenty-one percent incorrectly identified the appropriate lane for which passing is permitted. Although 70 percent of the film viewers and 69 percent of the remaining survey respondents were aware of the passing and no-passing combination indicated by these lines, their knowledge of the meaning according to lane was not determined. Signs in Texas which read DO NOT CROSS SOLID YELLOW LINE IN YOUR LANE TO PASS are apparently not as successful in raising level of understanding as those that accompany double solid yellow lines.

5. Solid White Line



I. Structured Responses to solid white dividing lanes (Slide Survey and Field Survey)

58% - one-way traffic

40% - passing not permitted

II. Unstructured Responses to acceleration lane (Film Survey)

65% - lane divider that should not be crossed

11% - incorrect interpretation of the solid white line

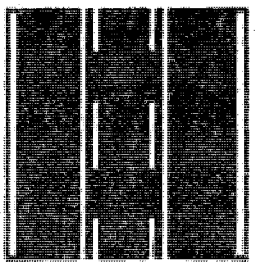
A solid white line that is four to six inches wide is used to delineate lanes of travel in the same direction where passing is discouraged. A wide white line, twice the width of a normal line, is used for emphasis where crossing requires unusual care and is frequently used to delineate left or right turn lanes.

In the film, respondents saw the white line used to separate an acceleration lane from through lanes on a highway. Sixty-four percent defined the line as a dividing line that should not be crossed; two percent defined it as a lane divider that may be crossed, while three percent mentioned only that the line divides lanes. Twenty-one percent saw the solid white pavement markings as an indication of a merging situation, but did not specify crossing restriction.

The diagram in the slide and booklet survey featured a road with a normal solid white line in the center. The purpose of this out-of-context representation with no situational cues given was to determine the level of understanding of the white, solid coding system. It was determined that just over half (58%) of those surveyed recognized white as signifying one-way traffic, and less than half (40%) recognized the solid line as a caution against crossing.

The use of white to represent one-way traffic is apparently ineffective. Furthermore, the advisory characteristic against crossing the solid white line is not understood by 60 percent of licensed drivers.

6. Two-Way Left Turn Lane Striping



I. Structured Responses (Field Survey)

59% - left turn lane
5% - passing lane
21% - emergency stopping area
13% - don't know

II. Unstructured Responses (Slide Survey)

56% - left turn lane
5% - passing lane
7% - emergency stopping area
31% - other incorrect interpretation of two-way left turn striping

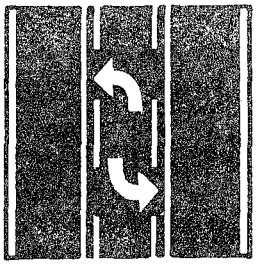
On a five lane roadway where there are two lanes of through traffic in each direction, a two-way left turn lane is reserved in the center for exclusive use of left turn vehicles. This lane is not to be used for passing and overtaking or for travel by any driver except to make a left turn.

Of all survey respondents who were asked to identify the purpose of this lane in a diagram, only 58 percent answered correctly. Five percent thought the lane was for passing; six percent suggested it was for emergency stopping; and 31 percent either admitted they did not know the purpose of the lane or gave unique incorrect responses indicating a lack of understanding of this lane's purpose.

Pavement markings that are sometimes used within the left turn lane were tested for their effectiveness in adding to the understanding of this lane. This information was obtained during the in-depth interviews and is discussed in the following section.

7. Two-Way Left Turn Lane Pavement Markings

I. Unstructured Responses (Film Survey)
93% - arrows indicate turn lane

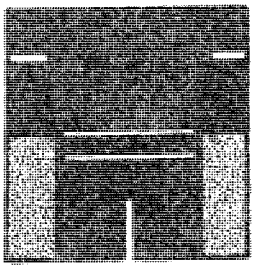


Pavement markings increased the understanding of the two-way left turn lane substantially. Ninety-three percent of the 91 respondents who were shown film footage of the turn lane with left turn arrows painted on the pavement identified the purpose of the lane correctly. Of those who were incorrect, two percent reported they would not travel in a lane with arrows. Other misconceptions included the belief that the lane was for turning right, or for turning left or right, or that an abrupt turn was indicated by the arrows.

To summarize, pavement markings are found to significantly increase recognition of the purpose of two-way left turn lanes. Whereas only 58 percent were able to correctly identify the turn lane with no arrows visible, 93 percent showed a sufficient knowledge level in a simulated driving situation where pavement arrows were displayed. It is recommended that these markings be used in conjunction with the lane delineations as often as possible.

8. Pedestrian Crosswalk Lines

I. Unstructured Responses (Slide Survey)
75% - pedestrian crosswalk
25% - incorrect interpretation of pedestrian crosswalk lines



Although the primary purpose of crosswalk markings is to guide pedestrians in proper paths, they also serve to warn the motorist of a pedestrian crossing point and legally define a stopping point. A diagram of a standard crosswalk marking was shown to 87 respondents. Three-fourths correctly identified the white parallel transverse markings as a pedestrian crosswalk. Eight percent interpreted the markings as stop lines for an intersection. Eighteen percent had no comprehension of the meaning of the white transverse lines.

A condition was specified in which stopping would be required, and respondents were asked where vehicles should stop. Eighty-six percent would stop at the first white line they come to, while seven percent would stop at the second white line. Several respondents (4.5 percent) cited the appropriate stopping point as the first white line, whereupon movement to the second line is allowed when no pedestrians are using the crosswalk. This is incorrect and is an obvious problem for pedestrians who arrive at a crosswalk after a motorist with this misconception.

Whenever possible, the accompaniment of appropriate crossing signs with crosswalk markings is suggested in order to facilitate recognition of the crosswalk by motorists. Educational strategies to inform motorists of the proper stopping point should be considered.

OVERVIEW - ROAD MARKINGS

In general, survey respondents indicated a lack of understanding of the meaning of the road marking code system. Comprehension of the coding system when presented with no environmental cues was low for several of the markings. In simulated (filmed) driving situations in

which some environmental cues were provided, improved understanding was evidenced; however, thorough comprehension of the meaning of any one road marking in a driving context was not found.

Respondents showed little understanding of the difference between yellow and white in defining directions of travel. Additionally, although a reasonably good understanding of markings that do not permit passing was found, there was some indication that the premise drivers use was the color yellow, rather than solid versus dashed markings.

Driver Characteristics and The Effectiveness of Road Markings

Problems in understanding road markings were analyzed according to driver characteristics. The relationship of many characteristics (some of which included age, sex, ethnicity, education, place of residence in the state, number of years of driving experience, the completion of driver education and defensive driving courses, number of miles driven per year, driving as a part of job requirement and proportion of urban to rural miles driven) to comprehension of the road marking code system was examined.

The findings showed that those drivers with the highest level of understanding were those who had taken a driver education course. This characteristic was the most important to overall understanding of the road marking code system.

Drivers in the sample surveyed who took driver education tended to be young males who drove fewer miles per year than older drivers, and had taken the driver education course within the last two years. Also, there was a porportionally higher percentage of drivers in Houston and

Palestine that had taken driver education. El Paso had a significantly lower proportion of drivers who had taken the course.

The defensive driving course was advantageous for understanding one road marking--the two-way left turn lane. Defensive driving could not be associated with any significant increases in knowledge for any other marking.

As mentioned previously, there was a positive relationship between having taken driver education and understanding the road marking system; and those who took driver education were young. Therefore, in general, younger drivers expressed a greater level of comprehension of road markings than older, more experienced drivers. However, there was a slight variance for certain age groups. The youngest category of drivers (14 to 24 year olds) were more knowledgeable on the one-way characteristic of white markings. Twenty-five to 34 year olds revealed a significantly lower level of understanding for this marking, even though a large portion of this group had taken driver education within the previous five years. Drivers 35 years and older as well as those with more driving experience, were more often incorrect on the meaning of white pavement markings. Twenty-five to 54 year olds had a strong tendency to incorrectly respond to the ability to cross a solid line in the lane of travel.

The probable cause for the misunderstanding by older age groups is the changes in meaning that have occurred during the driving years of the older respondents. In Texas, for example, any driver over 40 years of age has been exposed to four major alterations in the delineation of the center of a two-way highway. Thus, in the case of lines, being an

experienced driver, even with driver education, can be viewed as a disadvantage due to the exposure to inconsistent markings over time. The most recently licensed drivers with driver education training are the most knowledgeable about the current road marking system.

IV. DRIVER UNDERSTANDING OF REGULATORY SIGNS

In a previous research effort (Koppa, et al, 1978) knowledge levels of drivers were explored through a survey approach in five large urban and five small Texas cities. Twenty-seven traffic control devices were included in the survey, based on recommendations from driver education and defensive driving instructors, State Department of Highways and Public Transportation staff, and previous studies. Of the eleven traffic controls that were discovered to be seriously misunderstood, seven were signs. Based on these results, it was determined that more intensive examination of public understanding of signs was necessary. Using the previous findings as a starting point, and with the advice of an advisory panel of the State Department of Highways and Public Transportation, new approaches were developed in which more detailed information could be obtained. In addition to further assessment of the knowledge levels of Texas drivers with regard to correct identification of specific signs, information was sought concerning awareness of the signing shape and color codes, identification of the symbology, and interpretations of certain signs within a driving context. A total of 63 signs were included in the study, although very limited and specific information was obtained for several of these.

In 1977 a study was conducted (Quane) that produced some unexpected results concerning student drivers' knowledge of traffic sign shapes and messages. 293 Illinois students in their late teens and early twenties were given a Family Safety test. The students were asked to draw the proper shape around standard messages and symbols, and to put correct

messages or symbols inside seven unique standard shapes. Only seven items of the twenty on the test were answered correctly by an average of four out of five respondents, and 50 percent of the items on the test were answered correctly by 50 percent of those tested. The respondents had more difficulty drawing the proper shape for messages and symbols than identifying the message when the shape was given. For instance, the STOP sign, YIELD sign, and RAILROAD CROSSBUCK were identified by their shape alone by most students. However, SCHOOL CROSSING and diamond shaped warning signs were missed quite often. The author concluded that the shapes of signs are not well understood and that education programs need to emphasize the meaning of sign shapes.

A study conducted by the American Automobile Association for Traffic Safety in 1979 (Hulbert, et al.) concentrated on the meanings associated with traffic control devices as they are seen on the road. Nine signs were presented to 3,164 motorists from all areas of the country. This extensive coverage of drivers enabled the researchers to make comparisons by region of the country and by the age and sex of drivers.

In general, it was found that motorists understood symbol signs better than either signals or pavement markings. However, even the best understood signs were not correctly interpreted by five to ten percent of the drivers tested. One significant finding was that motorists did not fully understand and recognize the significance of the color orange for signs indicating highway construction zones.

Hulbert, et al. also found that drivers over 50 years old had less thorough knowledge of traffic control devices; drivers aged 24 to 49

showed the best understanding; and younger drivers (under 24) showed slightly better comprehension than older drivers. Additionally, a few significant differences were observed in certain traffic control situations between male and female drivers and among regions of the country.

The above studies are representative of research that points to the need for a comprehensive study in this area. In this report, findings are presented that are intended to be more broad-based and at the same time more in-depth than previous studies of public knowledge of the meaning of signs.

EVALUATION OF SIGN EFFECTIVENESS

The function of signs is to present regulatory information at specific places or at specific times, or to inform motorists of hazards that are not self-evident. Signs also serve to give information as to highway routes, directions, destinations and points of interest. Thus, the function of signs is not merely to confirm rules of the road.

Each sign is displayed for specific purposes that are highly standardized. As important as standardization with respect to design is uniformity of application. The MUTCD states that "identical conditions should always be marked with the same type of sign, irrespective of where those particular conditions occur" (1978: 2A-2). It is therefore reasonable to expect that drivers would be able to interpret signs in any one context appropriately. The film survey portion of this study is based on this assumption.

With regard to symbology, a preference for the use of symbols rather than words is expressed in the MUTCD as a "desirable and impor-

tant step toward the greater safety and facilitation of traffic" (1978: 2A-6). Recently the procedure for removal of educational plaques defining symbol signs was altered. In the past the intent was that "an orderly transition to a consistent symbol system is desirable and should proceed as rapidly as public acceptance and other considerations permit" (MUTCD, 1971: 16). Currently, the procedure has been changed; each new warning or regulatory symbol sign erected that is not readily recognizable by the public is to be accompanied by an educational plaque for not less than three years. Additionally, the MUTCD states that "no special effort need be made to remove educational plaques as long as they are in serviceable condition" (MUTCD, 1978: 2A-6).

The following sections detail the findings specific to each sign. This information conveys the current status of the public's recognition and comprehension of both symbol signs and word message signs.

REGULATORY SIGNS

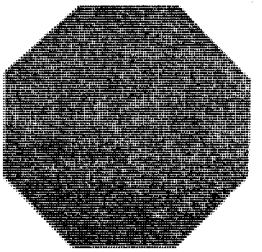
The first 12 signs to be examined are regulatory signs. These signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent. However, unnecessary overuse should be avoided.

Regulatory signs can be classfied into four groups. Some regulatory signs do not impose any obligation or prohibition, but serve as operational controls. For instance, signs that give advance notice of a requirement are classified as regulatory signs. Signs classified in the right-of-way series (stop and yield), the speed series, the move-

ment series (turning, alignment, exclusion, and one-way), and the miscellaneous series are included in this analysis.

1. Stop

The STOP sign was tested for shape and color recognition. Respondents knew the background color of the STOP sign more than any other sign - 87% gave red as the correct color. Only 56% drew the correct eight-sided figure. 78% correctly identified a red, octagonal shape as a STOP sign.



The STOP sign is the most common traffic control device in the United States as well as internationally. Its red color and octagon shape are used almost universally. Because of the frequency in which drivers encounter this sign, and the universal characteristic of its shape and color, it was expected that the STOP sign would be recognized by the largest percentage of the driving public.

This sign was tested solely on the basis of shape and color recognition. Out of 30 signs, the STOP sign ranked tenth in percentage of correct answers, when the word 'stop' was omitted. Seventy-eight percent correctly identified the red, octagonal shape as a STOP sign. Eleven percent thought this shape and color sign would mean slow down. A significant number of this 11 percent were drivers over 55 years of age. These were also drivers with more years of experience. Three percent suggested the sign meant "yield", and seven percent did not recognize the shape and color at all. Two percent of those surveyed

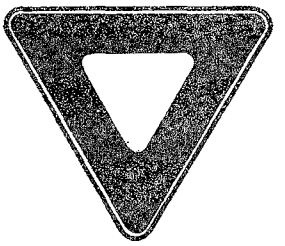
said they would ignore this sign if the word 'stop' was not written on it.

Respondents were given a card with the word 'stop' written on it and asked to draw the proper shape around it to make a traffic sign, and to give the correct background of the sign. Eighty-seven percent correctly associated the color red with the STOP sign. This was the highest percentage of correct responses for background color of the 25 signs in this survey. Twelve percent of the incorrect responses were yellow.

Unexpectedly, the percentage of respondents who drew the correct octagonal shape was low. Only 56 percent drew the correct eight-sided figure. An additional 18 percent drew a hexagon around the word 'stop', and 14 percent made the sign circular. Although technically these shapes are incorrect for the STOP sign, they are visually similar to the octagon. Allowing for the difficulty in drawing the octagonal shape, the percentage who drew a shape resembling a standard stop sign was 88. The remaining 12 percent drew rectangles, squares, diamonds, and various nondescript shapes.

It was concluded that the STOP sign is not as widely recognized as would be expected by its unique shape and color. The word 'stop' must be visible on the sign to be identified by 22 percent of the driving population.

2. Yield



The YIELD sign was tested for shape and color recognition. 25% correctly identified the background color, and 40% drew the correct shape. 83% of the respondents to the field survey recognized the meaning of the YIELD sign by its shape and color.

The YIELD sign has been designated with a unique shape for easy identification, and the color red to emphasize its regulatory purpose. Prior to 1971, yield signs were yellow. Survey results show a lack of awareness of the change in color to red.

Only 25 percent of those surveyed correctly identified the background color of the YIELD sign. The majority (62 percent) maintained that the color of YIELD signs was yellow. Because prior to 1971 all YIELD signs were yellow (and although it is not known how many, a few remain on local streets), it was expected that yellow would be recalled frequently. Interestingly, however, a correlation was not found between older drivers and statement of the red YIELD sign as yellow. In fact, 78 percent of those who identified the YIELD sign as yellow were under 45 years old. Twenty-eight percent were under 24 years old and began driving after the change in standard color had been made. When respondents were later informed of the correct color, several insisted they could not remember seeing red and white YIELD signs.

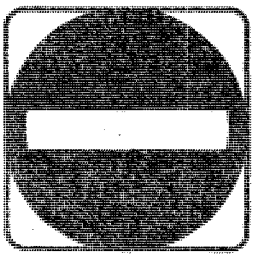
Fewer people knew the correct shape of the YIELD sign than knew the STOP sign. However, more people knew the shape than the color of the YIELD sign. Forty percent correctly drew a downward pointing triangle to make the sign. Twenty-two percent knew the correct shape, but drew it upside-down. Another 22 percent made the YIELD sign diamond shaped.

Recognition of the meaning of the YIELD sign by its shape and color was determined in the statewide survey. Eighty-three percent of those surveyed correctly identified the meaning of the downward pointing, red and white triangle. Eleven percent checked the "don't know" response. In this case age was a factor, as significantly fewer young drivers checked the "don't know" response.

Understanding of the YIELD sign symbology is not as thorough as would be expected, based on 17 percent incorrect responses when shape and color were presented and respondents were asked to give the meaning. It can also be concluded that recall of this traffic control device is very low for such a unique sign, given that only 25 percent correctly named the background color and 62 percent drew the proper shape.

3. Do Not Enter

The DO NOT ENTER symbol was tested without the words on it. 45% responded correctly to the field survey. 34% admitted they did not know the meaning of this symbol.



The DO NOT ENTER sign is a 30-inch white square on which is a 29-inch diameter red circle, with a white band five inches in width placed horizontally across the center of the circle. The design of this sign is supposed to make recognition very easy for the driver, even at a distance. The red color alerts the driver to a prohibitory regulation.

In the statewide survey using the booklet questionnaire, the DO NOT ENTER symbol was presented without the words on it to determine the level of understanding of the symbol itself. Forty-five percent

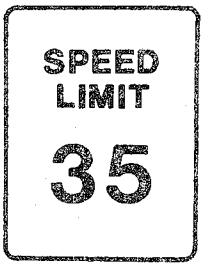
responded correctly. A significant 34 percent did not know what the symbol was, and 20 percent thought the symbol related to emergency facilities. Apparently the symbol itself is not effectively communicating the message printed on it.

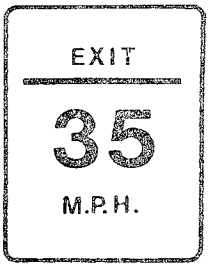
Those who understood the DO NOT ENTER sign tended to be young, newly licensed drivers who had taken driver education. A significant number of those who had not had driver education checked the "don't know" category, rather than 'guessing' the other categories.

The MUTCD specifically states that this sign should be conspicuously placed in the most appropriate position at the end of a one-way roadway or ramp. In light of the findings of this study the conspicuousness of placement is especially important. Because drivers are dependent much more on the words than the symbol for DO NOT ENTER, it is most important that they have time to see and respond accordingly. Ideally, motorists should be educated as to the meaning of the large red circle with a white band, because this is more visible at a greater distance than the words written on it.

4. Speed Limit and Advisory Speed

The majority of respondents recognized the regulatory and advisory speed signs as indicating a driving speed, but did not distinguish the two signs. 24% correctly distinguished the yellow advisory from the white regulatory SPEED signs.





The speed limit sign was included in this study, not so much to discern if drivers understand the meaning of it, but to determine if

they distinguish the regulatory feature of this sign from others. First, the speed limit sign was included on the shape and color survey.

Respondents were shown the very common message, SPEED LIMIT 55, and asked to identify the background color and shape of this sign. In general, this sign does appear to be well known, relative to others. Eighty-two percent correctly stated the background color to be white, and 87 percent drew a verticle rectangle or square shape to make the sign. Next to the STOP sign, the SPEED LIMIT sign was second most known in terms of its color, and has the most well-known shape.

The ADVISORY EXIT SPEED sign also was tested in the shape and color survey. In standard format, EXIT, 35 MPH was presented. Forty-three percent said the background was white and 30 percent said it was yellow. Eighty-one percent surveyed drew a verticle rectangle or square shape to correctly delineate this sign.

To assess motorists' knowledge of the difference between regulatory and advisory speed signs, both were presented in the film survey. Respondents were shown an exit ramp advisory speed sign and immediately following it, a regulatory speed limit sign of the same speed. They were asked to explain what each sign meant, and what, if any, differences there were between the two signs.

All but five percent identified each sign as a speed limit sign. Fifteen percent identified the ADVISORY EXIT SPEED sign as a speed limit, while 80 percent specified that this sign pertained to speed going off a freeway ramp. In defining the ADVISORY EXIT SPEED sign, no respondents mentioned the advisory nature of it.

Eight-six percent of those surveyed explained that the regulatory SPEED LIMIT sign notifies the driver how fast he may drive. Probably as a result of the previous freeway exit speed sign, 12 percent specified a location of this sign, i.e., speed limit in the city, or speed limit for neighborhoods.

When asked to explain the difference, if any, between the yellow and white speed signs, respondents showed a certain amount of creativity, but little concrete knowledge. Fourteen percent claimed there was no difference between the signs. Another three percent maintained that the only difference was in color, and no difference existed for meaning.

Many of those surveyed used environmental cues seen in the film to describe the difference in the two signs. For instance, 16 percent said the difference was that one was specifically for an exit ramp. Two percent suggested the ADVISORY SPEED sign was used for curves or bridges. Fifteen percent said the different signs were used for different areas of town; and 10 percent stated that the yellow speed sign was for reducing speed and the white speed sign meant that speed is to be maintained. Twenty-four percent made the distinction of the yellow speed sign as advisory from the white SPEED LIMIT sign that is regulatory. Thirteen percent made no attempt to guess, but simply stated that they did not know the difference.

From the in-depth interview findings, it is apparent that most drivers respond to both the advisory and the regulatory speed signs in the same manner. The finding that 95 percent defined both signs as setting a speed limit indicates that an appropriate driving reaction is

elicited from each sign; however, the effectiveness of color coding yellow for an advisory speed is minimal.

5. The Prohibitory Symbol

An average of 66 percent explained the meaning of the right turn prohibition sign in the in-depth interviews. 89% checked the correct response for this sign in the field survey. Seven percent gave this sign a meaning opposite from the intended one, responding "right turn only."

The prohibitory symbol is increasingly being used internationally to convey the message that the pictured item behind the symbol is not allowed. As its adoption for use on roads has recently become more widespread and includes a large variety of prohibited actions, the question to be addressed is how well the public understands the prohibitory meaning of this symbol as applied to traffic movement.

A right turn prohibition sign was included on each of the four survey approaches. Knowledge of the standard shape and color of this regulatory sign was the objective of the first approach. These characteristics were each correctly identified by approximately 42 percent of those surveyed.

In response to a slide of the right turn prohibition sign, 64 percent stated that the symbol means vehicles may not turn right. Eleven percent were unable to define the sign. Seven percent thought that only right turns are permitted, which is consistent with earlier studies (Koppa, et al., 1978).

Approximately the same level of understanding was evidenced when the right turn prohibition sign was approached in the simulated driving portion of the survey. Sixty-eight percent explained the prohibition against turning right correctly. Five percent said the sign meant to turn right! This was in spite of environmental cues presented in the film, most significantly including a ONE WAY sign indicating direction of traffic movement. Seven percent could not identify the sign, even in a filmed driving sequence.

In the statewide survey, respondents were given four alternative definitions for the right turn prohibition sign. These were: 1) detour, 2) left turn only, 3) no right turn, and 4) right turn only. The percentage of correct answers improved dramatically with the provision of these choices. Eighty-nine percent of the 373 drivers surveyed checked the third definition, no right turn. However, the second most frequently checked answer was the fourth one, right turn only. As with the slide presentation, seven percent gave this sign a meaning that is opposite from the intended one. Given the probability of turning onto a one-way street the wrong way, the ramifications of this percentage of misunderstanding are very serious. The fact that understanding improved by only two percent in a simulated driving context emphasizes the problem; the difficulty is not an inability to make an appropriate response apart from an actual driving context.

Misunderstanding of the prohibitory right turn sign was correlated with several driver characteristics. Drivers with the most years of driving experience were more likely to check the "right turn only" and "don't know" responses. These drivers were characteristically older and

without driver education. There was also a tendency for blacks to respond incorrectly to this sign more than the other three ethnic groups. Also, drivers who checked "detour" were drivers who later suggested they did not always pay close attention to traffic control devices.

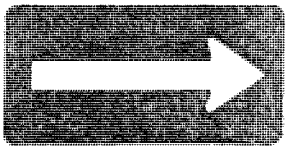
The prohibitory symbol was presented in the survey booklet with no picture behind it, to determine if motorists identified the concept of the symbol as it applies to any driving situation. The most frequently checked response category was "don't know" (37 percent). More males than females correctly identified the meaning of this symbol. Thirty-four percent of the respondents knew that the symbol indicates a prohibition against traffic or movement. Perhaps the use of the color red explains the inclination of 15 percent of those surveyed to believe this symbol represented a civil defense shelter, and 10 percent to believe it represented a hospital zone. The civil defense misconception was more commonly held by older drivers (65 years and older). An additional five percent assumed that the symbol itself meant "no smoking". In contrast to the prohibited right turn, misconceptions of the probitory symbol were held by a significantly greater number of young drivers, and by females.

From the above findings, it is obvious that the concept of the red circle and slash is not well understood by two-thirds of Texas' drivers. Understanding is improved considerably when the prohibited item or action is added to the symbol. However, because five to seven percent of drivers have an opposite interpretation of this symbol (i.e., only

instead of no), it is strongly recommended that word messages accompany this sign.

6. One Way Traffic

Respondents tended to confuse the ONE WAY TRAFFIC sign with a DETOUR or a SHARP TURN sign when no word messages were provided. 48% correctly interpreted this sign in the slide survey. In the field survey, 72 percent identified the ONE WAY sign from among ONE WAY, DETOUR, and SHARP TURN signs.



The most common misinterpretations of the white arrow on a black horizontal rectangle (or the ONE WAY sign) were drawn from the in-depth interviews. Subsequently, in the statewide survey, Texas drivers were presented with a set of responses to the ONE WAY sign that would be most confusing in their driving experiences. Motorists' ability to recognize the symbology of the ONE WAY sign was the tested variable.

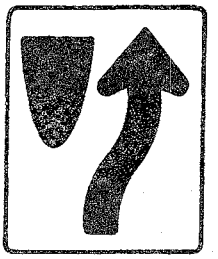
Confusion on this sign was primarily with the DETOUR sign; in in-depth interviews 12 percent of the responses to the ONE WAY sign suggested that this traffic control meant "detour". Another 11 percent gave "sharp turn" as a response. Twenty percent did not know what the arrow meant when the words were omitted and no written choices were provided for them. Less than half (48 percent) of the respondents correctly identified the ONE WAY sign in the open-ended slide presentation.

When drivers had to make a decision among the one way, detour, and sharp turn options their recognition of the ONE WAY sign improved a great deal. In the booklet survey, 72 percent correctly identified the ONE WAY sign with no words on it. Eighteen percent perceived the sign

as a DETOUR sign, and seven percent perceived it as a SHARP TURN sign. Only two percent said they did not know what the sign meant in the booklet survey.

Although drivers never encounter the ONE WAY or DETOUR sign without the words written on them, it would be advantageous if they could distinguish these two signs by color alone. Knowledge of the white versus yellow versus orange rectangular arrows would aid motorists in immediate recognition and speed reaction to the situation.

7. Keep Right



The KEEP RIGHT sign was most often confused with the DIVIDED HIGHWAY sign. 67% answered correctly in the field survey, and 41% gave correct interpretations of the KEEP RIGHT sign in the slide survey.

According to the MUTCD, " the KEEP RIGHT sign should be used at the ends of medians, parkways, loading islands, and refuge islands, at traffic islands, and at underpass piers, where traffic is required to keep to the right." These standards are pointed out to clarify the meaning as it differs from the DIVIDED HIGHWAY sign. The KEEP RIGHT sign was found to be confused most often with the DIVIDED HIGHWAY sign in the slide presentation and in the statewide booklet survey.

When drivers were asked to explain the KEEP RIGHT sign, 41 percent indicated that there is an island, median, or obstruction and the sign informs drivers they should keep right. Twenty-three percent confused the sign with the DIVIDED HIGHWAY sign. Ten percent thought the sign

meant curve to the right. Another 25 percent gave incorrect meanings or described inappropriate driving responses.

Keep right, divided highway, curve, and detour, were possibilities provided for each respondent to identify with the KEEP RIGHT symbol in the booklet survey. Two-thirds (67 percent) checked the appropriate response. Twenty-seven percent checked DETOUR and four percent checked CURVE.

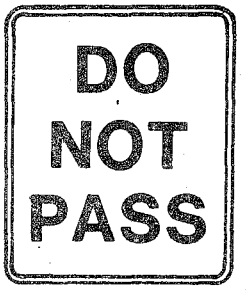
Not only did respondents confuse the meaning of the KEEP RIGHT sign with the DIVIDED HIGHWAY sign, but they also tended to equate the two in appearance. When asked to identify the color background of the KEEP RIGHT sign, more than half (55 percent) said "yellow." Only 31 percent gave the correct color, white. Furthermore, 20 percent drew a diamond shape to make a KEEP RIGHT sign.

The implication of confusing the KEEP RIGHT sign with the DIVIDED HIGHWAY sign is that in responding to the KEEP RIGHT as if it were a DIVIDED HIGHWAY sign the driver will move to the right. However, this interpretation gives the driver a false sense of security regarding his position relative to opposing traffic. Since the KEEP RIGHT sign is often used to mark obstructions where traffic is required to go to the right for a very brief section of roadway, the misinterpretation of this sign may present a potentially dangerous situation where the undivided highway is not immediately apparent to the driver. Fortunately, environmental cues are usually prevalent in situations where the KEEP RIGHT sign is warranted. Nevertheless, when placing the KEEP RIGHT sign, the confusion with the DIVIDED HIGHWAY sign should be noted -- the

traffic engineer should be certain further action based on environmental cues is self-explanatory for the driver.

8 Do Not Pass

76% gave an appropriate shape for the DO NOT PASS sign. 60% gave an appropriate color. The shape and color of the DO NOT PASS sign was not confused with the NO PASSING ZONE pennant.



The DO NOT PASS sign was included in the shape and color portion of the survey. The reason for its inclusion was to determine respondents' knowledge of the regulatory shape and background color. Additionally, a comparison of the DO NOT PASS regulatory sign and the NO PASSING ZONE pennant, based on shape and color recognition, was undertaken.

The shape of the DO NOT PASS sign was generally well known. Seventy-six percent described the shape as either square or vertically rectangular. Six percent described the shape as circular, and the remaining 18 percent gave an assortment of shapes. Only one respondent confused the pennant flag with the shape for this message.

Less well known than the shape, but widely recognized relative to other signs, was the background color. Sixty percent correctly stated that white was the background color for the DO NOT PASS sign. However, 25 percent gave yellow as the background color.

In summary, there does not seem to be a great deal of confusion between the DO NOT PASS sign and the NO PASSING ZONE pennant based on the two differing shapes. There does appear to be a lack of awareness

of the regulatory status of the DO NOT PASS sign, based on a 24 percent error rate for shape and a 40 percent error rate for color.

9. Double Turn

Seventy percent in the slide survey and 81% in the film survey described appropriate driving maneuvers for the DOUBLE TURN sign. When choices were presented in questionnaire form concerning appropriate maneuvers, the percent correct was lowered to 53%.

Whenever turning volume exceeds the capacity of one turning lane, and when all movements can be accomodated in the lanes available to them, multiple-lane turns are warranted. In these situations, lane-use control signs are required.

In the previous TTI study of Public Understanding of Traffic Control Devices (Koppa, et al., 1978), the left DOUBLE TURN lane-use control sign was included in a diagnostic survey. In this study undertaken three years ago, 28 percent of those surveyed suggested that only the left lane could be used for turning. Moreover, 20 percent of the participants indicated that a driver in the left turn lane also had the option of continuing forward through the intersection. The severity of these mistaken ideas warranted further analysis of the left DOUBLE TURN lane-use control sign. Therefore, it was included in each of the four survey approaches for this study.

A large majority of the respondents to the shape and color survey had an accurate perception of the shape of this regulatory sign. Eighty-one percent drew a four-sided figure, either a square or

rectangle. This sign's color was not as widely known. Fifty-eight percent stated the color was white, 19 percent said yellow, and 13 percent suggested green.

Ninety-four respondents were shown the left DOUBLE TURN lane-use control sign on a slide and asked to explain what it communicates to drivers. The explanations given can be classified into five groups. Seventy percent described an appropriate driving maneuver -- incorporated in the explanation was that drivers in the left lane must turn left and those in the right lane may turn left or go straight. Twelve percent gave a response that described an inappropriate driving maneuver; for example, drivers in the left lane must turn left and drivers in the right lane must go straight, or drivers in the right lane must turn right and drivers in the left lane must turn left. Eleven percent described turning maneuvers that made no differentiation between lanes, such as drivers must turn left or drivers must go straight. Five percent gave the sign a completely wrong identification, such as curves ahead. Finally, one percent could not give any explanation of this sign.

The same respondents were shown an approach to this sign as if in a moving vehicle. Using a film of an actual driving situation the respondents were given the following information and asked these questions:

> "You see this sign as you approach an intersection. You are in the second lane from the left. What does the sign tell you? What does it tell you if you are in the far left lane?"

In this case, where respondents were required to define the rules for each lane, four types of answers emerged. They were:

1. The left lane must turn left, and the right lane can go left or straight - 81 percent.
2. The left lane must turn left, and the right lane can go right or straight - 1 percent.
3. The left lane turns left, and the right lane turns left - 4 percent.
4. The left lane turns left, and the right lane goes straight - 13 percent.

These data indicated that the ability to interpret the left DOUBLE TURN sign increased by 11 percent with the film approach where movement was a factor. Additionally, an improvement in understanding from the level observed in the 1978 study (Koppa, et al.) can be reported. As noted earlier, 28 percent of those surveyed in the previous study believed that only the left lane could be used for turning, compared to 13 percent of those surveyed by film in this study. Secondly, and more important, no participant in the current study suggested that the driver in the left turn lane had the option of continuing forward through the intersection, whereas, 20 percent indicated this to be the case in the previous study.

The next approach was to examine more closely exactly how well drivers throughout the State understood the left DOUBLE TURN sign when several options are given to them. Respondents were asked to identify the one most correct of the following four statements:

20% 1. To turn left, you must be in the lane on the left.

53% 2. To go straight, you must be in the lane on the right.

14% 3. You may go straight or turn left in the left lane.

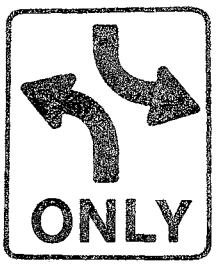
11% 4. You must go straight if you are in the lane on the right.

From the percentages that checked each response, it is clear that some confusion as to what can and can not be done still exists. The accuracy with which people could explain the sign lowered when written choices had to be made, as opposed to telling how to manuever in a traffic scene. The poor understanding exhibited on both written surveys (1978 and the current one) is quite possibly due to the difficulty in reading and thinking through the options given. This hypothesis is supported by the fact that a correlation was evidenced between incorrect responses and the use of English as a secondary rather than primary language in the home. Nevertheless, only one percent checked the "don't know" category, which indicates incorrect responses were checked as if the respondents felt they knew the correct answer.

To summarize the findings on the left DOUBLE TURN sign, it can be said that although some problems in understanding do exist, the effectiveness of this sign is greater than it appears to be from structured questionnaire data. The regulatory feature of this sign was not well known, according to background colors given. Respondents could tell, in their own words, how to respond to this sign much better than they could select a correct written statement. The difference was a 17 percent improvement in verbally explaining a picture of the sign, and 27 percent greater accuracy when describing what to do in an approach to this sign on film in a real-time format.

10. Two-Way Left Turn Only

The majority of motorists (74%)comprehended the information displayed on the TWO-WAY LEFT TURN ONLY sign in the context of a driving situation. A very low percent understood the sign out of context (20%). This was the second most misunderstood of the regulatory signs in the absence of situational cues.



The TWO-WAY LEFT TURN ONLY sign is confusing to a significant segment of the driving population because of a few common misconceptions. The two primary misconceptions revolve around (1) where to turn and (2) the proper direction of the turning manuever.

In response to the booklet survey, only 20 percent checked the appropriate statement, "use the center lane only for turning left." The percentage who correctly defined the sign in the slide presentation was also 20 percent. Another 40 percent responding to the slide presentation could explain what driving maneuver the sign required them to do, without categorically defining the sign. When a driving scene was displayed on film, 74 percent could correctly describe what the CENTER LANE, TWO-WAY LEFT TURN ONLY sign on the side of the roadway meant.

The confusion associated with this sign was brought to surface with the slide and booklet surveys. With only the sign itself as a cue to its meaning, 13 percent of the 94 slide survey respondents said the sign dictated a left or right turn. Four percent said the sign signified a curve in the road. Twelve percent gave an incorrect identification of the sign that could not be categorized, and six percent stated they did not know the meaning of the sign.

In the booklet survey, 5 percent checked that the TWO-WAY LEFT TURN ONLY sign means to turn left at these angles immediately, whether desirous of turning or not. Sixty-four percent associated the sign with a required movement that is to occur at the next intersection. Of this 64 percent, 33 percent stated the motorists must turn left at the next intersection, and 31 percent suggested a required turn either left or right at the next intersection. It is interesting to note that the driving segment with problems on this sign was the newly licensed. Drivers who received their license on the day of the survey checked incorrect responses most frequently. Ten percent of the survey respondents said they did not know what the sign meant.

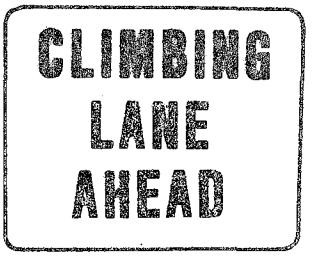
A composite look at the findings of each of the survey approaches reveals that the majority of motorists (74 percent) comprehend the information displayed on the TWO-WAY LEFT TURN ONLY sign in the context of a driving situation. However, knowledge is very low concerning the meaning of the sign itself. No doubt drivers are more receptive to pavement markings and the location of this sign than the message written on it, according to the very low percent who showed understanding (20 percent) of the sign out of context. In summary, pavement markings convey the two-way left turn only message much more clearly than the sign designed for this communication.

Although these findings reveal a breakdown in communication of the symbol message provided by this sign, it is probably not a problem that affects critical desisions that must be made in split seconds. It is recommended that research focusing on the extent to which this sign is ignored in lieu of attention to pavement markings would illuminate the

criticality of the location of placement for this sign. Signs with arrows and the word "only" were generally found to be ambiguous to the motorists.

11. Climbing Lane Ahead

The CLIMBING LANE AHEAD sign was identified by 60% in in-depth interviews; of this proportion, only 3% could describe the appropriate driving maneuver associated with the sign. 80% chose the correct response in the structured field survey. This sign has been deleted from Texas MUTCD.



CLIMBING LANE AHEAD has been classified as a miscellaneous regulatory sign. It has been excluded from the recently published Texas MUTCD (1980). However, this sign remains as a traffic control on the roadway system and analysis of driver understanding of the sign is warranted. Because the CLIMBING LANE AHEAD sign was being considered for exclusion as a standard sign at the time this study began, efforts were made to assess public awareness and knowledge of this verbal message.

When 94 drivers were asked to explain the meaning of these three words during in-depth interviews, only 60 percent indicated they were receiving the right message from this sign. More telling is the fact that 16 percent thought the sign simply meant the motorist was about to go up a hill. Another 13 percent did not know the meaning of this sign.

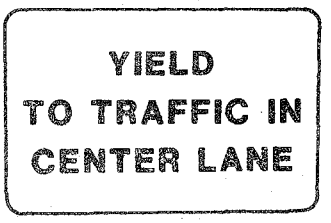
Eight percent of those surveyed statewide responded "don't know" to the CLIMBING LANE AHEAD sign, although alternatives were provided for

them to choose among. Six percent chose the response "mountainous area --watch for falling rocks." Four percent knew a lane was added for slower traffic going up a hill, but thought it was added on the left. Eighty percent chose the correct answer.

The significant finding that emerged from the in-depth interviews pertaining to this sign was that, even if drivers can explain the meaning of the words, CLIMBING LANE AHEAD, there is some question as to what this sign is telling them to do. Only three percent described an appropriate driving maneuver. It is questionable in the minds of motorists what this regulatory sign is regulating. A supplemental message for slower traffic to use the right lane 500 to 750 feet later clarifies the purpose of this sign. However, because it is superfluous to use the two together, it is appropriate to exclude the CLIMBING LANE AHEAD sign for use. When a lane is added on the right, SLOWER TRAFFIC KEEP RIGHT should be sufficient.

12. Yield To Traffic In Center Lane

Respondents had a lower level of understanding of this sign than any regulatory signs that were explained verbally. 13% gave an appropriate driving response. 76% gave wrong answers and 11% said they did not know the meaning. This sign has been deleted from the 1980 Texas MUTCD.



YIELD TO TRAFFIC IN CENTER LANE is another miscellaneous regulatory sign. This sign was designated for use in the signing of climbing lanes to establish priority in the use of the center upgrade through lane, with the climbing vehicles having preference over descending vehicles.

In the recent publication of standards associated with traffic controls, the YIELD TO TRAFFIC IN CENTER LANE sign was excluded. However, it remains on the roadway system. Because this verbal message sign was being considered for exclusion as a standard sign at the time the study began, efforts were made to determine driver understanding of this traffic control.

A great deal of variety was evidenced in explanations of the meaning of this written message given by slide survey respondents. In their own words, 13 percent gave an appropriate driving response, which was most often similar to "you are going down a hill--if you want to pass, you must give the opposing center lane traffic the right-of-way."

With no cues as to the location on a hill where this sign would be, 17 percent said the center lane is a turning lane and oncoming traffic should give the right-of-way to cars turning. Nineteen percent claimed that the center lane of traffic has the right-of-way, and did not specify in what instances. Another 41 percent gave various incorrect maneuvers that drivers should make, such as "slow down for cars in the center lane," or "stop for cars in the center lane." Eleven percent could not give any explanation for this word message sign.

As noted, this sign has been deleted from the Texas MUTCD. The purpose of traffic signing is to describe conditions that are not otherwise self-evident. One obvious rule of the road is that cars driving in their own lane automatically have the right-of-way in reference to traffic in the opposite direction. The confusion resulting from this sign is evidence that this "rule of the road" does not need reinforcing with a lengthy word message sign.

OVERVIEW - REGULATORY SIGNS

The regulatory group of signs are critical traffic controls because they inform highway users of the law, and because they establish right-of-way. This information is vital to motorists who must obey the legal mandates that are intended to make driving safer. Some regulatory signs are more critical than others. Ideally, these signs would be clearly understood by virtually all drivers. The findings above do not support these premises.

Strictly in terms of percentages, the most difficult of the regulatory signs tested in the surveys for Texas drivers to understand is the YIELD TO TRAFFIC IN CENTER LANE sign. The most effective regulatory sign, based on level of understanding, is the SPEED LIMIT sign.

None of the signs assessed are completely comprehended by all the respondents. Ninety-five percent recognized the meaning of the SPEED LIMIT sign; yet, only 24 percent could explain the difference between a yellow and a white SPEED LIMIT sign.

In general, the standard shapes and colors for regulatory signs were not well known by the drivers in study samples. The STOP sign was the most well known of all, recognized by 87 percent of the respondents. The SPEED LIMIT sign's correct shape was also correctly interpreted by 87 percent, which was the highest percent correct on shape.

Of the nine signs for which background color was requested, five ranged from 25 to 43 percent correct. These same nine signs were all in the top half of the percent correct on shape for the 25 signs in the survey. The range was from 40 to 87 percent correct for shape. Per

centages correct for shape and color for each of the regulatory signs are given in Table 4.

Table 4.
Results of Shape and Color Survey for Regulatory Signs

Sign	% Correct Color	% Correct Shape
1. Stop	87	56
2. Yield	25	40
3. Prohibitory Turn	43	53
4. Speed Limit	82	87
5. Exit Speed Limit*	30	81
6. Do Not Pass	60	76
7. Double Turn	58	81
8. Two-Way Left Turn Only	41	49
9. Keep Right	31	52

*Advisory sign - included for comparison with standard regulatory.

To question respondents as to the meaning of symbol signs, word messages were taken off the signs where necessary. Overall, the YIELD sign is understood better than other signs with the verbal cues removed. However, the shape and color of the YIELD sign are not easily recalled by most drivers.

Knowledge of the signs was assessed under various circumstances; in some cases signs were not shown in an environmental context, and in some cases written choices were provided. Additionally, three regulatory

signs were presented in the simulated driving context of the film. For the DOUBLE TURN and TWO-WAY LEFT TURN ONLY signs, understanding improved considerably in the "real world context" over the picture of the signs (11 percent for the former and 14 percentage improvement for the latter). Understanding of the prohibitory symbol improved only slightly in the film survey from the slide survey (from 64 percent to 68 percent). Overall, respondents did best choosing the appropriate meaning from a list. A summary of the correct percentages for each regulatory sign by survey type is given in the table below.

Table 5.
Percent Correct Responses of Regulatory Signs
by Survey Type

SIGN	SHAPE	COLOR	SLIDE	FILM	STATEWIDE QUESTIONNAIRE
1. STOP	56	87	---	---	78
2. YIELD	40	25	---	---	83
3. DO NOT ENTER	---	---	---	---	45
4. SPEED LIMIT	87	82	---	95	---
5. PROHIBITORY RIGHT TURN	53	43	64	68	89
6. ONE-WAY TRAFFIC	---	---	48	---	72
7. KEEP RIGHT	52	31	39	---	67
8. DO NOT PASS	76	60	---	---	---
9. DOUBLE TURN	81	58	70	81	53
10. TWO-WAY LEFT TURN ONLY	49	41	60	74	20
11. CLIMBING LANE AHEAD	---	---	60	---	80
12. YIELD TO TRAFFIC IN CENTER LANE	---	---	13	---	---

It is concluded that the shape and especially the color code as it relates to regulatory signing is not well known by Texas drivers. Additionally, the meaning of the symbology and word messages were not as well understood as would be expected when presented out of context. (The range of correct answers was 13 to 70 percent.) Respondents had less difficulty answering questions pertaining to pictures of signs than explaining the meaning of the signs in their own words (except with the DOUBLE TURN sign). The mean percent of correct responses regarding regulatory signs on the statewide questionaire was 65 percent.

V. DRIVER UNDERSTANDING OF WARNING SIGNS

Warning signs are used when it is necessary to point out existing or potentially hazardous conditions on or adjacent to a highway or street. The signs require caution on the drivers's part and may suggest a reduction in speed or a special driving manuever. Adequate warnings improve traffic safety and assist in the efficient movement of traffic.

There are 10 locations and hazards that may warrant the use of warning signs in addition to miscellaneous conditions to which the driver should be alerted. These are:

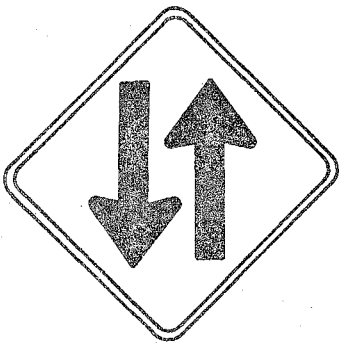
1) Changes in horizontal alignment
2) Intersections
3) Advance warning of control devices
4) Converging traffic lanes
5) Narrow roadways
6) Changes in highway design
7) Grades
8) Roadway surface conditions
9) Railroad crossings
10) Entrances and crossings

The most commonly used warnings signs for these locations and hazards were included in at least one of the survey approaches of this study.

As mentioned previously, a wider adoption of symbols in preference to word messages has been stated in the standards manual as an important step toward greater safety and traffic facilitation. One of the goals of this research, particularly in regard to warning signs, is to deter-

mine how well symbol signs are understood. The ability of drivers to interpret symbol signs that are not yet common is also analyzed in this section.

1. Two-Way Traffic Symbol



I. Structured Responses (percent correct)
98% - field survey
79% - slide survey

II. Unstructured Responses
43% (yellow color) } *shape and*
14% (diamond shape) } *color survey*

Well understood traffic control device.

A TWO-WAY TRAFFIC sign is used to warn motorists of transition from a separated one-way to a two-way roadway. This sign was comprehended very well relative to other warning signs. In the survey undertaken statewide, TWO-WAY TRAFFIC was the most understood sign. Ninety-eight percent of the respondents answered correctly.

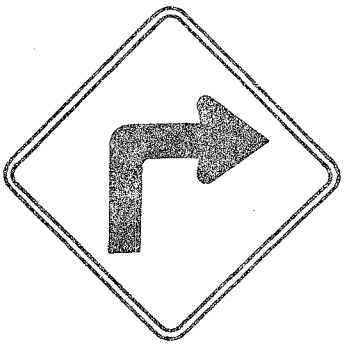
Knowledge was not as clear cut when measured in the in-depth interviews. Seventy-nine percent appropriately defined the meaning of the sign. Four percent said the sign indicated two lanes of traffic but did not specify directionality. Another four percent interpreted the sign to mean "go straight ahead". Nine percent gave miscellaneous erroneous responses, and four percent stated they did not know the meaning of the sign.

Respondents were, overall, not familiar with the standard shape and color of the TWO-WAY TRAFFIC sign. Forty-three percent identified the background color as yellow, and only 14 percent drew a diamond shape

around the message. This seemingly well known sign was among the lowest in recollection of its physical appearance.

The results indicate that respondents are very capable of matching the legend, "two-way traffic", with the sign. However, some confusion surfaced during the in-depth interviews, which suggests that drivers are not completely familiar with this symbol sign in the absence of an educational plaque.

2. Turn Sign



I. Structured Responses (percent correct)
62% - field survey
82% - slide survey

II. Unstructured Responses
80% - film survey
53% (yellow color) } *shape and*
18% (diamond shape) } *color survey*

Advisory Speed plate is warranted on all turn signs because drivers cannot easily distinguish the TURN sign from a CURVE sign.

The TURN sign is used specifically where a turn is to be made that requires a speed of 30 MPH or less. The severity of the change in horizontal alignment was the point emphasized in the inquiries. It was on this point that respondents faltered most frequently.

A left TURN sign was presented to the respondents of the statewide survey. They were asked to designate it as a left TURN, left CURVE, KEEP RIGHT, or DETOUR sign. Sixty-two percent responded left TURN, while 35 percent responded left CURVE. Two percent interpreted the sign

as meaning DETOUR, and one percent checked the "don't know" response category.

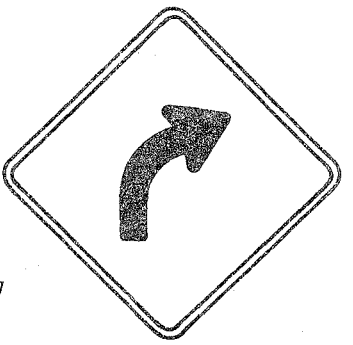
The severity of the turn was pointed out more often by the respondents to the slide survey. In 82 percent of the interviews the severity of the turn was mentioned. Eleven percent of those interviewed softened the severity considerably by calling the TURN sign a CURVE sign. Three percent could not define the sign.

Similarly, in the filmed approach to the TURN sign, with the geometrics of the roadway visible, 80 percent of those interviewed mentioned the severity of the turn, while 15 percent described the sign as a CURVE sign.

As with the TWO-WAY TRAFFIC sign, the commonly used TURN sign ranked poorly in recollection of its physical appearance. Fifty-three percent identified the background color as yellow, and 18 percent drew the appropriate diamond shape.

Since as much as 35 percent chose curve over turn, and 15 percent verbally described the TURN sign as a CURVE sign, it is suggested that the Advisory Speed plate is warranted on all TURN signs. No one in the in-depth interviews indicated any knowledge of a maximum safe speed to negotiate the turn. It is very likely that motorists, in general, do not know that a TURN sign indicates a safe speed of 30 MPH or less.

3. Curve Sign



Structured Responses (percent correct)
95% - field survey
75% - slide survey

Well understood sign. Confused with TURN sign, but poses less hazard.

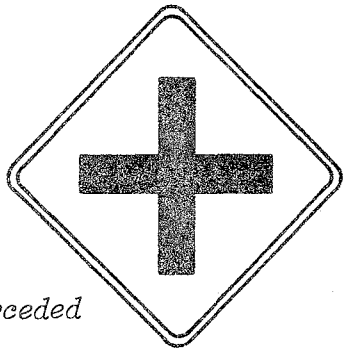
The CURVE sign is used specifically on curves where the recommended speed is in the range between 30 and 60 MPH. The Advisory Speed plate also may be used with the CURVE sign for additional information.

In the statewide survey a left CURVE sign was presented to the respondents, and left and right curve and turn options were provided. Ninety-five percent of the respondents correctly interpreted the CURVE symbol sign. One half percent did not know the sign and 4.5 percent designated it a TURN sign.

Similar results were not obtained in the in-depth interviews. When no response options were given to the respondents, 75 percent correctly identified the CURVE sign, although 22 percent called this sign a TURN sign.

In comparing the responses to the CURVE and TURN signs, the first observation is that a portion of the respondents were not able to correctly distinguish the two signs. It is interesting to note that respondents did not confuse the signs with each other in the in-depth interviews. That is, respondents who identified the CURVE sign as a TURN sign did not identify the TURN sign as a CURVE sign. Instead, of those who incorrectly responded, 31 percent said both signs were CURVE signs and 69 percent said both signs were TURN signs. Therefore, the problem appears to be a lack of distinction between the two signs.

Again, these findings amplify the need for Advisory Speed plates for both the CURVE and the TURN signs, given the propensity of many drivers to equate the two signs, and thus respond to them equally. However, the consequences of interpreting the CURVE as a TURN sign are much less severe than the reverse interpretation.



4. Cross Road Sign

Structured Responses (percent correct)
92% - field survey

Third sign in accuracy of identification, superceded by the TWO-WAY TRAFFIC and SIGNAL AHEAD signs.

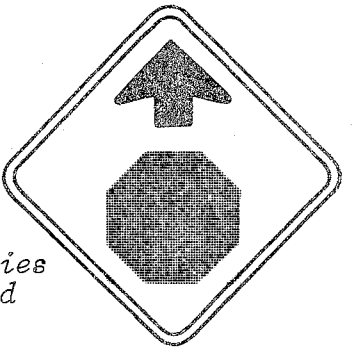
The CROSS ROAD sign is a simple symbol sign that is designed to indicate to motorists the presence of an obscured intersection. This easily recognizable symbol has been used for other purposes. It was included on the statewide survey to determine if confusion with other uses of this symbol exists.

The four choices provided were church, cross road, stop ahead, and railroad ahead. Respondents did well in giving the correct meaning of the sign -- 92 percent checked cross road. It would seem that, of the three remaining possibilities, church would be the most logical second choice, or that respondents may have believed stopping would be required. This was not the case. Two percent marked church, one percent marked stop ahead, three percent marked railroad ahead, and two percent checked the "don't know" response category.

Relative to other signs tested, the CROSS ROAD sign was well comprehended. It was the third most comprehended sign, superceded by

the TWO-WAY TRAFFIC sign and the SIGNAL AHEAD sign. Of those who did misinterpret the CROSS ROAD sign, a significant number were in the older age group, ages 55 and over.

5. Stop Sign Ahead



Structured Responses (percent correct)
42% - field survey
30% - slide survey

Educational plaques and other information strategies are warranted if this sign is to be used. The red octagonal symbol on this sign tends to be unidentifiable.

The STOP AHEAD and YIELD AHEAD signs have been commonly used when the announced sign is not visible for sufficient distance for the driver to react accordingly. Recently, new symbol signs have been introduced that will eventually replace the word message signs, although their use is not as common in Texas presently.

The STOP SIGN AHEAD symbol sign was included in the slide survey and in the questionnaire booklet survey that was administered statewide to determine if the driving public is accurately interpreting this new sign. In both surveys it was noted that many drivers had never seen this sign on the road before, and were interpreting it for the first time.

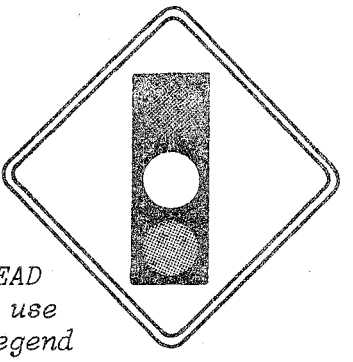
One common incorrect interpretation of the STOP SIGN AHEAD symbol sign was that the combination of the stop symbol and arrow indicated to the driver to stop and then go straight. Twenty-three percent of those interviewed described the function of the sign as such.

Another 21 percent said the sign meant to stop ahead. This is operationally correct, but the respondents did not indicate they would be looking for a stop sign, even though these drivers would prepare for a stop ahead.

Other interpretations of the STOP SIGN AHEAD symbol sign were uncovered with the in-depth interview approach. Among these were: directions to a football stadium, railroad sign, danger ahead, and blinking red light ahead. Overall, the meaning of this traffic control device was misconstrued by 60 percent of the respondents.

The statewide survey confirmed the confusion indicated in the responses to the slide survey. In this case, where four alternatives were provided, 45 percent checked "Stop, then go straight ahead" while 42 percent checked "Stop sign ahead." In contrast to the slide survey results, only three percent said stop at the next corner. In the in-depth interview (slide survey), 11 percent had no interpretation for the sign, and 10 percent of the questionnaire respondents checked the "don't know" response.

The findings suggest that the word message sign states more clearly the intended meaning of the STOP SIGN AHEAD symbol sign. Education and information transfer is needed to clarify the meaning of this symbol sign for drivers if it is be be put into common use.



6. Signal Ahead Sign

Structured Responses (percent correct)
94% - field survey

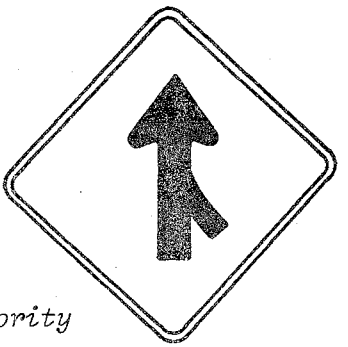
Contrary to the STOP SIGN AHEAD, the SIGNAL AHEAD symbol sign is well understood; it has been in use longer and has a more precisely identifiable legend than the STOP SIGN AHEAD sign.

Like the STOP SIGN AHEAD, the SIGNAL AHEAD symbol sign gives advance notice to motorists of a location in which the traffic control device (in this case, the signal) is obscured. This sign has been in use longer than the STOP SIGN AHEAD symbol sign; however, it has been customarily accompanied by an educational plaque.

Contrary to the STOP SIGN AHEAD symbol sign, the SIGNAL AHEAD symbol sign was very well understood. The SIGNAL AHEAD sign was the second most understood of all the signs included in the statewide survey. Only two percent said they did not know the meaning of the sign, and four percent incorrectly identified it. Ninety-four percent selected the signal light ahead response over green, red, and yellow light ahead options.

As with other symbol signs examined in this study, certain common characteristics of those who misinterpreted the SIGNAL AHEAD sign can be delineated. Specifically, the young and old drivers had incorrect interpretations most frequently. Also, drivers with the lowest average number of miles driven per year misinterpreted this sign.

7. Merge



I. Structured Responses (percent correct)
76% - field survey
63% - slide survey

II. Unstructured Responses
83% - film survey

The concept of MERGE is understood by the majority of drivers.

Based on previous research the MERGE symbol sign was hypothesized to be troublesome and was therefore included in each of the three survey approaches dealing with sign interpretation. It did not prove to be as troublesome as expected, with approximately 78 percent of the respondents for all tests having a clear conception of its meaning.

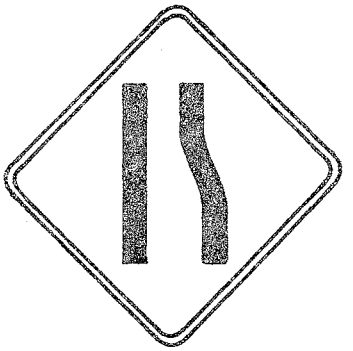
The MERGE symbol sign is commonly, but not exclusively, used to mark freeway entrance ramps. This prevalent usage may explain the 22 percent who designated this as the purpose or meaning of the MERGE sign in the questionnaire booklet. Seventy-six percent appropriately responded, "be alert for merging traffic."

When asked to give the name of the MERGE symbol sign as it was presented on a slide, 63 percent in some way communicated a merging situation. Only 11 percent defined the sign as a marking for a freeway entrance ramp. Four percent did not know the meaning of this sign.

The film survey clarified the symbology of the MERGE sign for some respondents. Although the MERGE sign was seen in a freeway situation with the merging lane being an entrance ramp, only four percent defined the sign as an entrance ramp marker in this case. Eighty-three percent of the respondents gave responses that had a merge meaning. Five percent could not give an explanation for the MERGE symbol sign.

The in-depth interview approach was helpful in determining the extent of respondents' knowledge of the meaning of the term 'merge'. It is one thing to identify the name of the sign which is often seen on an educational plaque, and another to explain the action to take place. An explanation was elicited in the film survey, and 83 percent were able to describe the meaning in their own words.

8. Pavement Width Transition



I. Structured Responses (percent correct)
68% - field survey
55% - slide survey

II. Unstructured Responses
46% - film survey

Need for educational plaque if used without LANE ENDS MERGE signs.

The PAVEMENT WIDTH TRANSITION is intended for use if advance notice is needed to warn of the reduction in the number of lanes, as from three to two lanes. In the interviews where the film and slide approaches were used it was determined that there is a great deal of variability in the interpretation of this sign. For instance, responses to a filmed approach to the PAVEMENT WIDTH TRANSITION sign included such diverse interpretations as divided highway ends, two-way road becomes one-way, side street merging into main street, curve, and two-way traffic. These were all multiple responses and not unique individual responses. Another eight percent of the interpretations were unduplicated individual misinterpretations. These were responses to a simulated

driving approach to the PAVEMENT WIDTH TRANSITION sign, where the respondent was in a position to see the change in the road.

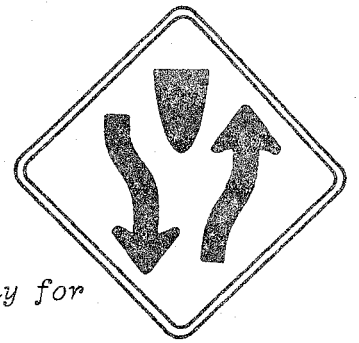
When presented the sign out of context (in slide form), respondents showed poorer comprehension than with the film presentation. Nineteen percent could give no definition of this sign. Three precent believed it meant the road curves. Twenty percent gave unique individual responses. Fifty-five percent could describe what the sign meant.

Based on in-depth interview responses, respondents to the statewide survey were given four choices: (1) Divided highway, (2) Dip in road, (3) Median narrows, and (4) Road narrows. Sixty-eight percent selected the correct answer. The most common incorrect answer was median narrows, with 18 percent checking this response. Four percent stated they did not know the meaning of this warning sign.

As with other symbol signs, the common threads among those who misinterpreted this sign were age, driver education, and years of experience as a driver. The older, more experienced drivers who lacked driver education were most apt to check inappropriate responses.

The PAVEMENT WIDTH TRANSITION sign is not presented in the MUTCD with an educational plaque. Instead, the LANE ENDS MERGE LEFT (RIGHT) sign is suggested as a supplement. Additionally, the (RIGHT) LEFT LANE ENDS sign is used in advance of either of these signs. This constitutes an abundance of signs to deliver a single message. Based on the lack of knowledge reported, it is recommended that in the event of a consolidation to a single sign to deliver this message, it be accompanied by an educational plaque.

9. Divided Highway Symbol



Structured Responses (percent correct)
88% - field survey
65% - slide survey

Some need for educational efforts, particularly for drivers with low educational levels.

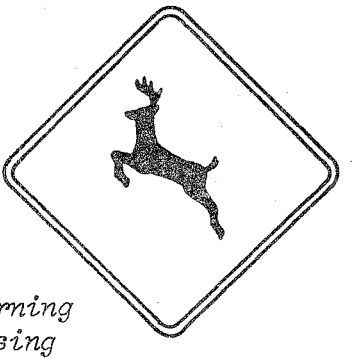
The DIVIDED HIGHWAY SYMBOL sign is a heavily utilized sign on Texas highways, and is usually accompanied by an educational plaque. Therefore, it was anticipated that Texas motorists would be very knowledgeable about its meaning. In general, it was found that Texas drivers could correctly identify this sign relative to other warning signs; however, less than 90 percent could accurately identify it.

Sixty-five percent of the respondents interviewed correctly identified a slide of the DIVIDED HIGHWAY SYMBOL sign, and 88 percent of the questionnaire respondents correctly identified its picture. No respondent to the questionnaire checked the 'don't know' response, although 8.5 percent of those interviewed did not recognize this symbol. Ten percent of the respondents interpreted the sign as a two-way highway sign or two-lane highway sign, and did not specify that it was divided.

The KEEP RIGHT sign was often confused with the DIVIDED HIGHWAY SYMBOL sign, but the reverse was not found. Only one percent of the respondents in the in-depth interviews held this misconception.

This sign was a problem for those with lower educational levels and for black and foreign drivers. It is recommended that any educational attempt be designed for these groups.

10. Deer Crossing



I. Structured Responses (percent correct)
96% - slide survey

II. Unstructured Responses
71% (color) } *shape and*
39% (shape) } *color survey*

Highest percent correct identification of warning sign shape. Good understanding of this crossing sign.

The DEER CROSSING symbol sign was included in the study for two reasons. First, as a simple and common warning sign it should reveal something about motorists' awareness of the shape and color of warning signs. Second, the crossing signs series used to warn drivers of unexpected hazards includes a variety of animals, machinery, and other items crossing the roadway. The DEER CROSSING symbol sign was chosen to represent the animal crossing series in order to evaluate understanding of this type of warning sign.

The color of this very typical sign was known to 71 percent of the drivers studied. Although less than three-fourths of the drivers were correct, it was the fifth most known of the 25 signs included on the shape and color survey. Furthermore, it was the third most easily recalled of the 10 warning signs tested.

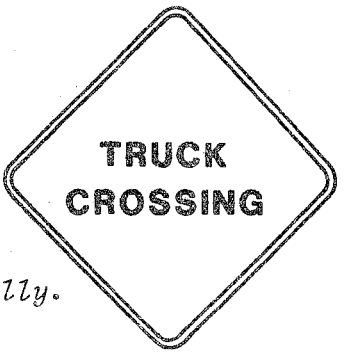
The shape of the DEER CROSSING symbol sign was drawn correctly more often than any other diamond shaped sign. However, only 39 percent of the respondents drew the correct diamond shape. Thirty-one percent of the respondents drew a square or a rectangle to make the sign.

Concerning identification of signs when presented in the in-depth interviews, the DEER CROSSING symbol sign was by far the most widely

recognized. Ninety-six percent of those surveyed correctly identified this sign. Another two percent said animals crossing. The remaining two percent gave responses that suggested an inappropriate driving response such as "yield".

To summarize, the DEER CROSSING symbol sign was very easily identified by the drivers surveyed. Also, they were generally more aware of its background color relative to other signs. However, respondents were not familiar with this sign's diamond shape. As discussed previously, this finding is consistent with Quane's (1978) and reinforces his conclusion that "the shapes of signs are not well understood."

11. Truck Crossing



Unstructured Responses (percent correct)
95% - film survey
59% (color) } *shape and*
29% (shape) } *color survey*

Lack of awareness of shape and color code generally. However, good understanding of this crossing sign.

A vehicular sign in the crossing series is the TRUCK CROSSING symbol sign. The study elicited reactions to this sign with the film approach. Like the DEER CROSSING symbol sign, it was included on the shape and color survey to substantiate evidence of drivers' awareness of the shape and color coding system for warning signs.

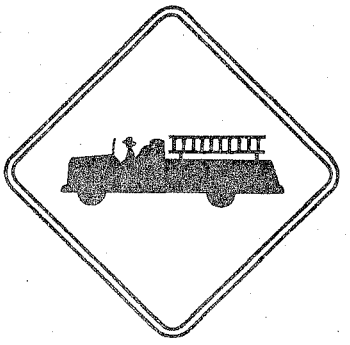
Respondents were not aware of either the shape or color of the TRUCK CROSSING symbol sign. Only 50 percent gave the correct yellow

color. Twenty-six percent gave the background color as white. Six percent said the background color was red.

Only 29 percent correctly drew a diamond shape to make a TRUCK CROSSING sign. A variety of other shapes were drawn as well. Twenty-eight percent drew rectangles and 18 percent drew squares. Five percent drew circular shapes and 7.5 percent simply stated they did not know the correct shape of this sign.

Reactions to the TRUCK CROSSING sign were almost all similar. All but two of the respondents gave reactions such as "watch for trucks, slow down and watch for trucks pulling out, or yield to trucks." This indicates that the TRUCK CROSSING sign is indeed self-explanatory to drivers. The fact that its shape and color were unknown to so many of the respondents is more evidence of the overall lack of awareness of the warning sign shape and color code.

12. Fire Station Symbol



I. Structured Responses (percent correct)
42% -field survey
70% - slide survey

II. Unstructured Responses
74% (film survey)
41% (color) } shape and
20% (shape) } color survey

Pictorial representation of fire truck on sign is not clearly identifiable by drivers as a fire station ahead, but drivers were generally aware of potential for a fire truck in area.

The FIRE STATION symbol sign is a part of the Crossing Sign Series. Its function is to warn motorists of the potential of sudden fire truck

traffic from a nearby station. It was learned that drivers associate the fire truck pictured with a fire truck route or crossing at the point of the sign, rather than a nearby station. For instance, in the slide survey 70 percent identified the sign appropriately by name or indicated an appropriate response such as "watch for trucks." Twenty-four percent identified the sign as a "fire truck" sign or indicated a fire truck crossing but did not show any awareness of the proximity of a fire station.

The film survey produced similar results. In this format another interpretation was introduced by the respondents. Three percent defined the sign as a TRUCK CROSSING.

In the questionnaire booklet distributed statewide, 42 percent of the responses were "fire station". Thirty-two percent interpreted the sign as a fire truck route; 13 percent indicated "fire lane", and seven percent "watch for trucks." Another seven percent checked the "don't know" response.

Respondents' lack of familiarity with the FIRE STATION symbol sign was exhibited in the shape and color survey. Forty-one percent designated the sign as yellow and 20 percent gave it a diamond shape.

The FIRE STATION symbol sign is an example of an attempt to convey a message in the simplest, most comprehensible form possible. Nevertheless, the meaning of the sign is not pinpointed by the picture on it. Although ambiguity results from the picture of the fire truck (i.e. fire station versus fire truck route versus fire lane, etc.) the danger of misinterpreting this sign was not found to be extreme, except

possibly in watching for trucks but not fire trucks. For the most part, drivers were aware of the potential of a fire truck in the area.

13. Pedestrian Crossing Symbol

I. Structured Responses (percent correct)
86% - field survey
81% - slide survey

II. Unstructured Responses
86% - film
74% (color) } *shape and*
21% (shape) } *color survey*

Most understood of the three crossing signs with pedestrian figures on them.

In the previous TTI study (Koppa, et al. 1978) it was discovered that three signs are often confused with one another. The SCHOOL ADVANCE, the SCHOOL CROSSING, and the PEDESTRIAN CROSSING symbol signs were seldom distinguished by the survey respondents. To examine further this overlapping interpretation, the three signs were included in both the in-depth interview and the statewide questionnaire approaches.

"Pedestrian crossing" was a common reponse to all three signs. Consequently, for the PEDESTRIAN CROSSING symbol sign presented in the survey booklet, the correct response was checked most frequently. Eighty-six percent correctly identified the PEDESTRIAN CROSSING symbol sign, which was preceded in the survey booklet by the SCHOOL ADVANCE and the SCHOOL CROSSING questions. It is possible that because the two school signs had already been seen, some elimination may have occurred. Only five percent checked "school crossing"; another five percent

checked "watch for children in the area"; two percent responded "school zone"; and two percent checked "don't know".

The PEDESTRIAN CROSSING symbol sign is distinctly different from the SCHOOL ADVANCE and SCHOOL CROSSING signs in both function and appearance. Lack of awareness (or recall) of the PEDESTRIAN CROSSING sign's appearance was found in the shape and color portion of the in-depth interviews. A relatively large percentage of the respondents designated the correct color for this sign. Seventy-four percent knew the sign was yellow, which was the fourth most recalled of the 25 signs included in the shape and color portion of the survey.

As expected, the shape was less well known. Twenty-one percent drew the appropriate diamond shape to make the PEDESTRIAN CROSSING sign.

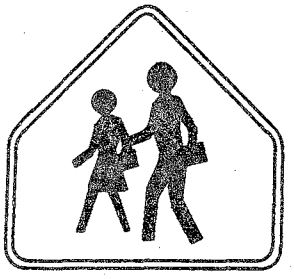
Respondents did very well in the identification of the PEDESTRIAN CROSSING sign when no choices were provided. Eighty-one percent could identify the sign. Although 19 percent incorrectly identified the PEDESTRIAN CROSSING symbol sign, only two signs were more frequently recognized - the TURN sign and the DEER CROSSING sign. Of those who did not correctly identify the sign, 8.5 percent were "don't know" responses. Interestingly, three percent of the respondents thought the sign represented a jogging trail marker.

When the same respondents were shown a filmed approach to a PEDESTRIAN CROSSING sign some identified it differently. Only two percent thought the sign represented a jogging trail marker in the film. One percent said they did not know what the sign meant. A higher

percentage associated the PEDESTRIAN CROSSING sign in the film with a school crossing.

In summary, the results show that the PEDESTRIAN CROSSING symbol sign was identified and understood by 86 percent of the field survey respondents. Recall of the appearance of the sign was not good - 74 percent knew the color, but only 21 percent knew the diamond shape that characterizes warning signs.

14. School Advance



I. Structured Responses (percent correct)
21% - field survey
24% - slide survey

II. Unstructured Responses
31% - film survey

The field survey allowed for comparisons among signs (the SCHOOL ADVANCE and the SCHOOL CROSSING) viewed by many drivers as highly similar, yet only 21 percent could select the appropriate meaning. This sign presents a difficult concept for the driver to assimilate, i.e., an advance versus an on-site traffic control device.

The SCHOOL ADVANCE sign is one of the traffic controls for school areas. Its purpose is to warn motorists of school buildings or grounds that are adjacent to a highway, or to give advance notice of established school crossings that are not adjacent to a school ground. Additionally, a SCHOOL ADVANCE sign is used in advance of every SCHOOL CROSSING sign.

In the MUTCD emphasis is given to the uniformity of traffic controls in all school areas.

> Pedestrian safety depends in large measure upon public understanding of accepted methods for efficient traffic control. This principle is never more important than the control of pedestrians and vehicles in the vicinity of schools. ...Non-uniform procedures and devices cause confusion among pedestrians and motorists, prompt wrong decisions, and can contribute to accidents. In order to achieve uniformity of traffic control in school areas, comparable traffic situations must be treated in the same manner (MUTCD: 1971, p.321).

The type of traffic control device used near a school is related to volume and speed of vehicular traffic, volume of pedestrian traffic, and street width. These factors are recognized in the MUTCD. However, "Uniformity is also heavily emphasized, because the use of similar controls in comparable situations aids in developing a consistent pattern of driving behavior in school zones." This factor draws attention to the importance of public understanding of school area traffic controls and points out that these signs should be displayed with regularity and continuity near all schools.

Respondents were asked to identify the SCHOOL ADVANCE sign presented on a slide. The instructions were that they give the name of the sign. It was not expected that drivers be able to uniformly cite SCHOOL ADVANCE as the correct name of the sign. However, the response sought was one that indicated proximity to a school or an approach to a crosswalk. This type response was given by only 24 percent of the slide survey respondents. They most often confused the SCHOOL ADVANCE with the SCHOOL CROSSING and PEDESTRIAN CROSSING signs. Thirty-eight percent said SCHOOL CROSSING and 36 percent said PEDESTRIAN CROSSING.

Responses varied slightly to the film segment of an approach to the SCHOOL ADVANCE sign. More drivers (36 percent) still associated the sign with a school crosswalk than advance warning of the crosswalk

(31 percent). Fewer interpreted the sign as a PEDESTRIAN CROSSING sign (30 percent), possibly due to the recognition of the school setting visible in the film.

To determine if drivers were able to make the distinction among the three signs, SCHOOL ADVANCE, SCHOOL CROSSING, and PEDESTRIAN CROSSING, these choices were provided with pictures of the respective signs in the questionnaire booklet. Using this technique, spontaneous terminology ceased to be a factor, and an assessment of conceptual differentiation was possible.

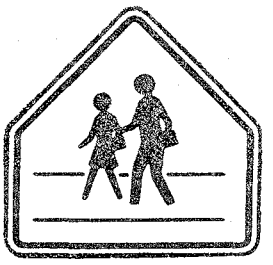
Even with the structured format, respondents failed to identify the appropriate meaning of the SCHOOL ADVANCE sign. The most frequently checked response was "pedestrian crossing" with 42 percent having this misinterpretation. The SCHOOL ADVANCE sign was designated a SCHOOL CROSSING sign by 36 percent of the respondents, and 21 percent checked the appropriate response, "you are in the area of a school." Additionally, one percent interpreted the sign as a bus stop, and one percent could not identify the sign.

The fact that motorists identified the SCHOOL ADVANCE sign inappropriately pointed to the need for determining the behavior elicited from the SCHOOL ADVANCE sign. Therefore, respondents who viewed the film were asked what they would do as they approached this sign. It was found that most drivers would, after seeing this sign, either slow down or be watchful for children or pedestrians, or a combination of these actions. Fifteen percent said they would be prepared to stop. Eleven percent stated they would exercise caution but

gave no specific reason. The most frequent action mentioned was "slow down", which was the response given by 42 percent.

Examination of the findings for the three approaches revealed that, overall, drivers were not aware of the difference between the SCHOOL ADVANCE sign and the SCHOOL CROSSING and PEDESTRIAN CROSSING signs. The encouraging finding was that a majority of motorists reported they would slow down or watch for children in response to the SCHOOL ADVANCE sign.

15. School Crossing



I. Structured Responses (percent correct)
50% - field survey
46% - slide survey

II. Unstructured Responses
44% - film survey
76% (color) } *shape and*
5% (shape) } *color survey*

Need educational strategy for general driving population for the school related signs and pavement markings.

The SCHOOL CROSSING sign was designed for use only at established crossings used by pupils going to and from school. These crosswalks must be adjacent to the schools, or on established school pedestrian routes. They are always preceded by a SCHOOL ADVANCE sign.

The SCHOOL CROSSING and SCHOOL ADVANCE signs both have unique shapes that distinguish them for school areas. Respondents were not able to recall the pentagon shape on the shape and color survey. Only

five percent drew the sign correctly. Color was much more known - 76 percent said the SCHOOL CROSSING sign was yellow.

The SCHOOL CROSSING sign was given the same treatment in the surveys as the SCHOOL ADVANCE sign. Because the tendency was for calling both the CROSSING and the ADVANCE signs CROSSING signs, there was a larger percentage who gave the correct response on each of the surveys. Specifically, 50 percent checked the correct response on the questionnaire. Forty-six percent correctly identified the sign on the slide survey and 44 percent described the correct meaning of the sign after seeing the filmed approach.

For those who incorrectly responded to the SCHOOL CROSSING sign, the most frequent interpretation was "pedestrian crossing." Over 30 percent in each survey gave this response. Approximately 13 percent gave a school zone interpretation rather than a school crossing.

There were no significant differences in personal characteristics among those who understood and those who misunderstood the SCHOOL CROSSING sign. It was anticipated that one segment of the population (female drivers of the age to have children in school) would be more knowledgeable concerning the meaning of school area signs due to the likelihood of their more frequent exposure. This was not the case, which highlights the need for an educational strategy aimed at all drivers for the school-related signs.

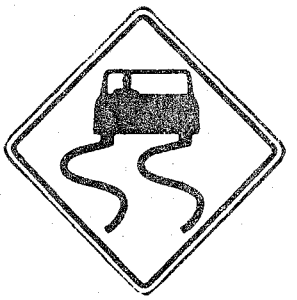
To summarize the findings for the three signs that represent pedestrian movement, it is clear that a significant proportion of drivers interpret all signs with a pictorial representation of people walking as pedestrian crossing signs. The pentagon shape of the school

area signs and the fact that the 'people' on these signs are carrying books apparently does not clarify the school area designation of these signs. Driver reaction to each of the three signs may be similar, but drivers do not appear to be watching specifically for children.

16. Slippery When Wet

I. Structured Responses (percent correct)
81% - field survey
54% - slide survey

II. Unstructured Responses
74% - film survey
71% (color), 38% (shape) - shape and color survey



Hazard associated with misinterpretation as winding or curving road; educational plaque should remain.

The SLIPPERY WHEN WET symbol sign was included in the previous TTI study (Koppa, et al., 1978). In this study 75 percent accurately perceived the sign, and 21 percent misconstrued the sign to mean the roadway winds or curves several times.

Some improvement in understanding was evidenced in the current study. In the field survey 81 percent correctly identified the SLIPPERY WHEN WET symbol sign, and only 16 percent misconstrued the sign to mean the road winds or curves.

One personal characteristic associated with incorrect identification of this sign was drivers' negative attitude toward the driving task. Additionally, the lower educated and ethnic minorities were most inclined to check the "don't know" response. Finally, a very

significant relationship was evidenced between respondents who were receiving their licenses on the day of the survey, and an inability to correctly identify the SLIPPERY WHEN WET sign.

The SLIPPERY WHEN WET pictograph is still often accompanied by an educational plaque. Therefore, it was expected that this sign would be identified verbatim by respondents in the in-depth interviews. The slight deviances that were observed provided insight into the nuances this sign has for a number of drivers.

Fifty-four percent of the respondents actually called the sign SLIPPERY WHEN WET. Twenty-one percent had a perception of the sign as indicating a slippery condition, but assumed the condition to be constant. In other words, they would respond, "slippery road" or "icy road", and failed to note that this warning was specific to certain situations.

Over five percent had no identification for this sign, and over six percent gave other wrong answers. Furthermore, 13 percent stated the sign meant curves ahead.

In the film survey, the predominant response (74 percent) was the correct interpretation. However, with environmental cues present, 15.5 percent maintained that the sign indicated curves ahead or a winding road. Nine percent did not know the meaning of the sign.

Like other warning signs, the appearance of the SLIPPERY WHEN WET sign was not well remembered by respondents. Seventy-one percent gave the correct background color, while only 38 percent correctly recalled the diamond shape.

The most striking misinterpretation of the SLIPPERY WHEN WET symbol sign is the association of winding road or curves ahead. This misconception poses a hazard for the misguided motorist. Posing no hazard is the identification of the sign as warning of constant slippery road conditions.

17. Pavement Ends

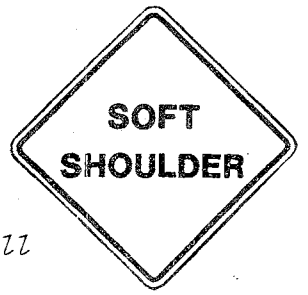
I. Structured Responses (percent correct)
75% - slide survey

Symbol sign may be more effective than the verbal message on the PAVEMENT ENDS sign.

A PAVEMENT ENDS sign is intended to warn where a pavement surface changes from a hard-surfaced pavement to a low-type surface or earth road. There are two PAVEMENT ENDS signs, one a pictorial, and one on which a word message is used. The word message sign was presented on a slide in this study, and respondents were asked to explain the meaning of the sign.

Seventy-five percent of the respondents were able to explain the meaning of the sign, or gave an appropriate driving response. Misinterpretation of the PAVEMENT ENDS sign was in the belief that the road stops completely, as in DEAD END. This misconception was held by 17 percent of the respondents. It is suggested that the symbol representation of the changes in the road's surface may be a more effective communication. However, since the symbol sign was not examined in this study, it is recommended that an assessment be made of its effectiveness before a preference for use is established.

18. Soft Shoulder

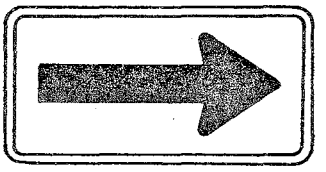


Structured Responses (percent correct)
85% - slide survey

The SOFT SHOULDER word message sign is well understood by drivers.

The SOFT SHOULDER word message sign was shown to respondents and they were to explain the meaning of the message. Eighty-five percent could explain this warning with acceptable accuracy. Responses showed some variability such as: "The shoulder is not a paved surface," "You might get stuck if you drive on the shoulder," or "Don't drive on the shoulder." Basically these 85 percent were receiving the intended message of the sign. However, the remaining 15 percent of the driver sample gave various incorrect identifications, said they did not know the meaning of the sign, or gave an inappropriate driving response.

19. Large Arrow Sign



Structured Response (percent correct)
18% - field survey

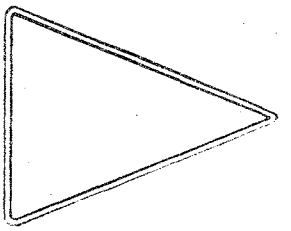
Problem of distinguishing among the LARGE ARROW sign, the ONE-WAY TRAFFIC sign, and the DETOUR sign color desgnations.

The LARGE ARROW sign is intended to give notice of a sharp change of alignment in the direction of travel. It is somewhat unique in that it is a warning sign that is rectangular rather than diamond shaped. Also, it is displayed on the outside of a curve or on the far side of an intersection at right angles to approaching traffic.

This sign was presented in the statewide questionnaire booklet with four options provided for its meaning. A relatively insignificant proportion (three percent) responded "don't know" and "dead end" (four percent). The majority of the respondents, however, interpreted the LARGE ARROW sign as indicative of a detour or one-way traffic. These two interpretations accounted for 75 percent of the responses. The remaining 18 percent correctly identified the arrow as indicative of a sharp turn.

Such findings illustrate the lack of awareness by motorists of the color coding system that is built into sign design. The LARGE ARROW displayed with the proper environmental cues provides effective communication. However, arrows are also used to delineate detours and one-way traffic. The distinciton (in addition to a word message) among the yellow, orange, and white sign color codes was not accurately perceived by the majority of motorists surveyed.

20. No Passing Zone



I. Structured Response (percent correct)
27% - field survey

II. Unstructured Responses
81% - film survey
1% - shape } color and
42% - color } shape survey

Problem of driver anticipation of comparable sign at the end of a no passing zone. This sign will be used selectively and currently is new to the public.

The NO PASSING ZONE sign is a recently implemented traffic control that has several unique characteristics. It has a pennant shape and it is always displayed on the left side of the roadway. This sign is supplemental to pavement markings and/or the DO NOT PASS sign. According to the MUTCD the sign is recommended because of its demonstrated target value in critical passing maneuvers.

The NO PASSING ZONE sign was examined in this study to determine if it has target value for Texas motorists. To be effective, it should be easily seen and easily recognized, particularly by its unique shape and color. Using this logic, the NO PASSING ZONE sign was included on the shape and color survey, the film survey, and the statewide questionnaire.

The pennant shaped NO PASSING ZONE sign is relatively new and is currently being introduced selectively on Texas highways. Therefore, it would be anticipated that drivers may have difficulty recalling its physical features. Only one percent of the respondents recalled the correct shape and forty-two percent gave yellow as the correct color.

Treatment of this sign in the film survey was a simulated approach to the sign. A close-up view of the pennant-shaped flag was afforded the respondents who were then questioned on several matters concerning the NO PASSING ZONE message.

Because of the close-up shot, the sign was reasonably readable, and understandable to 81 percent of the respondents. However, a significant 14 percent interpreted the sign to designate a construction area. It is not clear what features of this sign, or the sign's placement, precipitated this form of misunderstanding.

Another aspect of this sign that was studied was the extent and degree of its restriction. Because this pennant-shaped flag warns of a zone, questions that were raised were:

(1). Would drivers develop a dependency on this sign for information concerning passing to the neglect of other control devices, or

(2). Is the sign effectively providing redundant, reinforcing warning information?

To answer these questions, respondents were asked, "how do you know when it is safe to pass?" A surprising finding was that 49 percent said they would look for an equivalent sign at a later point stating that passing was permitted or the zone had ended. Thirty percent used pavement markings as guidance for passing; and eight percent responded they would look for either a sign or pavement markings to indicate permission to pass. Other respondents said "pass when you can see clearly" (seven percent), "pass when construction is passed" (one percent), and five percent did not know how to judge when to pass.

Finally, to further evaluate the effectiveness of the pennant shaped flag on the left side of the road, this symbol was included in the statewide questionnaire booklet. This question elicited a high "don't know" response - 43 percent. Unfamiliarity with this sign was evidenced in other responses: ten percent identified the sign as a YIELD sign, 17 percent indicated "drive friendly", three percent gave an interpretation of DEER CROSSING, while 27 percent said NO PASSING.

For this control device, a significant driver characteristic associated with knowledge was age. The younger drivers in the sample showed considerably more knowledge of the meaning of the pennant-shaped

flag than did older respondents. Other predominant characteristics among younger drivers with greater understanding of this sign were higher levels of education and recently being licensed. (Drivers who received licenses on the day of the survey were most familiar with the NO PASSING ZONE sign.)

In conclusion, the effectiveness of the the NO PASSING ZONE pennant is yet to be fully ascertained. Currently, Texas drivers are not very familiar with the sign. The word message is easy to understand, but the effectiveness of this sign lies more in perception and recognition. At this point, recognition of this sign is poor based on its physical appearance. There also appears to be a problem of the sign generating false anticipation of similar controls at the end of the no passing zone. The NO PASSING ZONE sign is new on Texas' highways and will be used selectively at particularly critical locations. Future evaluations are recommended.

21. Railroad Advance Warning Sign

I. Structured Responses (percent correct)
17% - field survey
2% - slide survey

II. Unstructured Responses
33% - film survey
40% - color } shape and
58% - shape } color survey

Public educational strategies should be directed at distinguishing on-site versus advance signing.

Traffic control systems for railroad-highway grade crossings have been the focus of a great deal of attention for several reasons,

including severity of accidents that occur at these locations. Except for airplane crashes, there is no other type of accident in the transportation world that is as severe as a collision at a railroad - highway grade crossing. A second reason for analyses of effectiveness of traffic controls at railroad grade crossings is the frequency of accidents occurring at these sites. There are about 365,000 rail-highway grade crossings in the United States, and each year 33,000 to 38,000 accidents, 5000 injuries, and 100 deaths occur primarily at public grade crossings (Sonefeld, 1979). Although safety at crossings is a very complex engineering problem, it has been pointed out that successful improvements are accrued by a combination of engineering programs and educational strategies geared at improving driver awareness. Sonefeld (1979:9) notes:

> Unlike many other highway-safety topics, very little if any attention has been given to rail-highway crossings in driver education or driver licensing courses. About two years ago, a national study of driver license manuals showed that some states almost completely avoided the subject and, even worse, some states actually gave misinformation about procedures at grade crossings. Furthermore, I have never seen a safety film made by a public agency on the subject of rail-highway crossings.

In Texas, pioneering work has been done to improve grade crossing devices. Some experimentation in design has been undertaken with the potential outcome for changes nationally. The RAILROAD ADVANCE WARNING sign is the standard now in use in combination with the RAILROAD CROSSBUCK. Instruction is given in the Texas driver license manual as to the meanings of these traffic control devices.

A preliminary analysis of written driver license examinations at Department of Public Safety (DPS) licensing stations revealed that

confusion exists over the RAILROAD ADVANCE WARNING sign. From a random sample of DPS tests, it was discovered that only 45 percent correctly answered the RAILROAD ADVANCE question. For this question a circular sign was presented and the responses were:

(1) Look out for a train;

(2) Disregard if you cannot read the sign; and

(3) Always stop, look, and listen.

Seventy-six percent of those who missed this question checked (3). This phrase - stop, look, and listen - is one learned at an early age to be associated with trains. It is not surprising then, that the phrase would be selected to correspond to the RAILROAD ADVANCE symbol. However, this association is not the correct meaning of the sign, nor does it convey an appropriate reaction for the motorist.

The previous study by Koppa, et al. (1978) revealed that drivers make inaccurate distinctions between the two railroad signs - the crossbuck and the advance crossing signs. Drivers confuse the on-site sign with the advance warning sign in this case. Such preliminary findings stimulated further interest in the effectiveness of the RAILROAD ADVANCE WARNING sign. Therefore, it was included in each of the four survey approaches.

Respondents were first asked to draw the proper shape and identify the background color of the RAILROAD ADVANCE WARNING sign. It was expected that drivers would be very familiar with these characteristics, especially the unique and yet simple circular shape. This was not the case, however. Only 58 percent correctly drew a circle to complete the RAILROAD ADVANCE WARNING sign, and 40 percent stated the background

color as yellow. Fourteen percent of the respondents made the sign square-shaped and 10 percent made the sign diamond-shaped. Thirty-four percent of the respondents thought the background color was white, and 19 percent stated the color was red. (This was a relatively large number of responses for red compared to other signs, and may be explained by the association with red and an alert to danger or by red and the circular shape.)

Only two types of responses were issued when a slide of the very common circular railroad sign was presented:

(1) a railroad crossing ahead; and

(2) the existence of a railroad, but no mention of a distance factor.

This latter, deficient interpretation was given by 98 percent of the respondents. It is noteworthy that none of the respondents gave deviant answers (unrelated to a railroad crossing) or responded "don't know".

A more in-depth approach was taken in the film portion of the survey. First, the respondent was asked the meaning of the RAILROAD ADVANCE sign as seen in a situation where no tracks were visible. Then further information was sought pertaining to driving response to the sign.' The respondents were also questionned regarding their expectation for other signs following this advance warning sign.

Again, almost all of the respondents gave one of two responses - railroad crossing ahead or railroad crossing. In this film situation, more respondents recognized the advance characteristic of the circular sign. Thirty-three percent gave an indication of a track ahead, while 64 percent gave the impression they thought the sign was at the track.

When asked what they do when they see the RAILROAD ADVANCE sign, 60 percent replied "slow down and look out for trains". Reflecting the on-sight versus advance confusion, 17 percent said they "stop and look for trains." Other responses were "look right and left" (seven percent), simply "slow down" (six percent), and "use caution" (seven percent).

By far the most critical of the two signs that mark rail-highway grade crossings is the RAILROAD CROSSBUCK sign, because this sign actually marks the crossing. It is important for drivers to know what to anticipate after they pass the advance warning sign. However, less than one-third of the drivers surveyed (30 percent) knew what sign follows the advance sign. More respondents admitted they did not know (36 percent), and seven percent stated that the sign that always follows is a STOP sign. An additional three percent said the sign located at the railroad crossing is the same sign as seen earlier. The remaining respondents suggested that traffic control devices other than a sign always follow the RAILROAD ADVANCE warning sign, such as the white pavement markings (three percent), red flashing lights (16 percent), and an automatic gate (one percent). The implications of these expectations can be serious. Red flashing lights and an automatic gate are active traffic control systems that are located selectively. A large number of important variables are considered when determining the need for an active device and there is no single standard for universal application of active traffic controls at grade crossings. Expectations for these controls are going to be in error in many cases, leading to a weakening of the effect of standard passive devices applied at all crossings.

The fourth survey approach, the statewide booklet questionnaire, confirmed that drivers fail to acknowledge the advance nature of the circular railroad sign. The four responses in the field survey were all related to a railroad situation. However, only one response indicated the approach to a rail-highway grade crossing. Thus, the question was intended to determine exactly how well respondents could define this sign with respect to its placement and meaning.

The first choice was "railroad crossing". This response was given by 76 percent of the respondents. The second alternative was "railroad track", which was selected by three percent of those surveyed. The correct answer, "railroad crossing ahead", was given by 17 percent of the respondents. A fourth response which was adopted from the driver license examination, "stop, look, and listen," was chosen by the remaining three percent of the respondents.

It was especially important that respondents carefully read the choices provided for this sign because of their similarities and the necessity for distinguishing among them. For this reason, this traffic control device was the first one presented in the questionnaire booklet. Respondents were encouraged at the outset to read all responses before choosing one, and it was assumed that this procedure would be followed more conscienciously in the beginning. Thus, the low awareness level of the meaning of the ADVANCE RAILROAD CROSSING sign found with the other approaches is reinforced with the field survey results.

The misunderstanding of the advance versus on-sight distinction concerning this railroad warning device was not correlated with any particular driving segment. All driving segments were equally

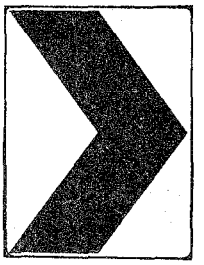
indiscriminate in their responses. It is recommended that public information and educational efforts address all drivers, and that consideration be given to a more explicit method of relaying to motorists that they are approaching a railroad-highway grade crossing.

22. Chevron Alignment Sign

Structured Responses (Percent Correct)
23% - field survey

Unstructured Responses (Percent Correct)
37% - slide survey
62% - film survey

Most common misinterpretation is for lane change. Warrants need to be established.



Under special conditions warning signs may be required that conform to some of the general specifications of warning signs, but are designed to meet unusual conditions. A recently designed and implemented warning sign is the CHEVRON ALIGNMENT sign, which is intended to provide additional emphasis and guidance for vehicle operators as to changes in horizontal alignment of the roadway. According to the MUTCD, a CHEVRON ALIGNMENT sign is a supplement to standard delineation treatments or can be used as an alternative or supplement to the LARGE ARROW sign.

The effectiveness of the chevron-arrow design has been evaluated in several states. According to an evaluation by the Oregon Department of Transportation (1977), this symbol sign is universally understood and provides a basis for a single uniform device to be used where emphasis is needed in communicating change in direction of alignment. The

Georgia Department of Transportation conducted research (1977) for two case problems using the chevron design and concluded that the chevron marker meets a previously unfilled need in delineation. As in Oregon, the Georgia DOT recommended its use for the sake of uniformity and standardization. However, an additional recommendation was made for the development of specific application criteria.

The latest edition of the MUTCD includes the CHEVERON ALIGNMENT sign and specifications for application. These signs are to be used on the outside of curves at right angles to approaching traffic. They are to be spaced so that motorists always have two in view, and they should be visible for at least 500 feet.

It would be unrealistic to expect that drivers could identify the CHEVRON ALIGNMENT sign by its official name. Respondents were asked to indicate in response to a slide that they had some knowledge that this sign informed the motorist of roadway alignment. From the physical characteristics of the sign alone, 37 percent recognized its communication. Fewer respondents in the statewide survey were able to distinguish the yellow CHEVRON sign. Twenty-three percent checked that it showed the direction of the road.

The drivers surveyed had a tendency to interpret the CHEVRON ALIGNMENT sign as an indication to change lanes. Twenty-one percent checked this response in the statewide survey. Seventeen percent said "change lanes" or "detour" in the in-depth interviews. These misinterpretations may be explained by the usage of orange chevron markers in construction and work zones. The chevron pattern has proved successful in diverting traffic and facilitation of lane changes in

construction areas. So effective has this specific application been that it is likely for the yellow chevron to be perceived to have this sole use also.

In the statewide survey, the CHEVRON ALIGNMENT sign received the highest percentage of "don't know" responses. Fifty percent of the respondents did not know or take a "guess" at the correct response.

It was anticipated that the positive guidance provided by the roadway alignment sign would be more readily understood by respondents viewing the filmed segment of marked alignment changes. The purpose of these signs is guidance. Therefore, no supplemental message or provison of information should be required for this sign to be effective. However, even in the simulated driving maneuvers through some problem curves, 38 percent of those interviewed did not know the purpose of this sign. Examples of the types of misinterpretations include: "keep to the right," "caution for trucks," "merging traffic," and "temporary signs indicating construction ahead."

The site selected and filmed for the interviews was one that consisted of a series of reverse curves. Perhaps the confusing aspect of the signing was the staggered, double-faced chevrons. Following the pattern as it changed from one side of the roadway to the other seemed to be problematic during the interviews. Single tangent curves were not included in the assessment.

Certain drivers had less difficulty interpreting the yellow CHEVRON ALIGNMENT signs - in particular, young drivers with little driving experience. Respondents who classified themselves as students were most knowledgeable on the meaning of this marker.

In summary, although other studies have shown the yellow CHEVRON ALIGNMENT sign to be an effective alternative to other types of road markers, two problems of the CHEVRON marker were highlighted in this research. The interpretation of this control was problematic when on both sides of a reverse curve. Additionally, its function as a channeling device in construction areas contributed to a perception of the necessity for a lane change. It is recommended that, in addition to application standards, warrants for use be determined, such as curve degree and accident experience.

OVERVIEW - WARNING SIGNS

There were several objectives in the analysis of the effectiveness of warning signs. A multiplicity of warning signs are encountered by drivers in all settings - urban and rural. The one common characteristic for all warning signs is their color. The diamond shape is the standard design, with few exceptions. An objective of this study was to determine the extent to which drivers know and use this information. The primary objective was to find out how well drivers interpret messages presented to them by warning signs, and relatedly, the effectiveness of symbology used on warning signs.

Table 6 shows the percentages correct for each of the warning signs included in the study. From 41 to 76 percent knew that warning signs are yellow, and on the average approximately one-fourth correctly identified the diamond shape. Incorrect descriptions were most often rectangular with white background.

Table 6. Correct Responses of Warning Signs by Survey Type

Sign	Percent Correct				
	Shape	Color	Slide	Film	Field Survey
1. TWO-WAY TRAFFIC	14	43	79	80	98
2. TURN	18	53	82	80	62
3. CURVE	-	-	75	75	95
4. CROSS ROAD	-	-	-	-	92
5. STOP SIGN AHEAD	-	-	30	-	42
6. SIGNAL AHEAD	-	-	-	-	94
7. MERGE	-	-	63	83	76
8. PAVEMENT WIDTH TRANSITION	-	-	55	46	68
9. DIVIDED HIGHWAY	-	-	65	-	88
10. DEER CROSSING	39	71	96	-	-
11. TRUCK CROSSING	29	50	-	95	-
12. FIRE STATION	20	41	70	74	42
13. PEDESTRIAN CROSSING	21	74	81	86	86
14. SCHOOL ADVANCE	-	-	24	31	21
15. SCHOOL CROSSING	5	76	46	44	50
16. SLIPPERY WHEN WET	38	71	54	74	81
17. PAVEMENT ENDS	-	-	75	-	-
18. SOFT SHOULDER	-	-	85	-	-
19. LARGE ARROW	-	-	-	-	18
20. NO PASSING ZONE	1	42	-	81	27
21. RAILROAD ADVANCE	58	40	2	33	17
22. ROADWAY ALIGNMENT	-	-	37	62	23

The most understood warning sign was the TWO-WAY TRAFFIC symbol sign. Relative to other warning signs, a good understanding of crossing signs (i.e., DEER CROSSING, TRUCK CROSSING, and PEDESTRIAN CROSSING) was evidenced.

There was a tendency to interpret advance warning signs of railroads, school crosswalks, and stop signs as on-site indications of each. With the statewide questionnaire the average score of correct answers was 60 percent. This was slightly less than the average percent correct for regulatory signs (65 percent). One traffic control singled out for having the highest "don't know" response of the study was the CHEVRON ALIGNMENT sign.

Symbol signs posed a problem for certain segments of the driving population. Ethnic minorities, older drivers, and the lower educated were more likely to misinterpret the intended meaning of the symbols. In several cases (e.g., SIGNAL AHEAD and SLIPPERY WHEN WET signs) respondents who had driven only a few years or less were unfamiliar with these symbol signs. On the other hand, newer signs, such as the PAVEMENT WIDTH TRANSITION sign and the NO PASSING ZONE warning pennant posed a problem for drivers with more years of driving experience.

Countermeasures were recommended to improve the effectiveness of warning signs. Generally, efforts to inform the public of the shape and color code for warning signs are needed. The continued use of supplemental information plaques was supported for some signs (e.g., NO PASSING ZONE, school area traffic controls, and advance warning signs). Public information and education efforts are recommended approaches for improving effectiveness.

Chapter VI. DRIVER UNDERSTANDING OF SIGNS FOR CONSTRUCTION AND MAINTENANCE OPERATIONS

For street construction, maintenance operations, and utility work, traffic control devices perform important dual functions. They serve to direct safe and expeditious movement of traffic through the work zones. Second, they insure the safety of the work force performing these maintenance or construction operations.

Because a vast number of conditions and situations exist, drivers do not encounter a set of traffic control devices that are a consistent or predictable pattern for all construction and maintenance operations. It is therefore of increased importance that drivers can easily and thoroughly comprehend the messages they receive as they move through these areas.

The same major categories of traffic signs--regulatory, warning, information and guide signs--apply to street or highway construction and maintenance signing with regard to their shape, and standard of application. However, warning signs in construction areas have a black legend on an orange backgound. To determine effectiveness, several of these specialized warning signs were included in the study, representing the signing used for construction and maintenance work zones.

1. Advance Flagger Sign

I. Structured Responses (percent correct)
62% - field survey
53% - slide survey

II. Unstructured Responses
64% - film survey
24% (color) } *shape and*
23% (shape) } *color survey*

Recommended use of educational plaque for improving understanding of the ADVANCE FLAGGER sign, in addition to distance messages.

The ADVANCE FLAGGER sign is one of the best examples of the important dual functions of work zone signs mentioned above. This sign provides advance notice of a situation where speed is adjusted dramatically, the motorist may be required to stop, and subsequent information is necessary to continue through the area. Additionally, driver comprehension of the sign is an important factor in the safety of the flagger.

Respondents were questioned regarding several aspects of this sign. They were asked first to give the appropriate physical characteristics. Less than 25 percent knew either the shape or the color of the ADVANCE FLAGGER sign. Thirty-five percent of the respondents thought that this sign was yellow. Twenty-four percent correctly said orange. Third in frequency among the responses was red, given by fourteen percent. Only 23 percent correctly drew a diamond shape to make this construction warning sign, while 37 percent made the sign square-shaped.

Of interest was the number of incorrect interpretations of this symbol sign. Specifically, 17 percent of those who were shown a slide and asked to define the sign described it as a school crossing guard

sign. Another two percent thought the sign indicated litter facilities. Five percent gave a "don't know" response. The third most frequent response was that construction or road workers were ahead. While this information is indicated by the sign, this is not the point of the sign; the 16 percent giving this response failed to be alerted to the fact that they would be approaching a person in or near the roadway giving flag signals necessary for guidance, which could be a serious mistake, for the motorist as well as the flagger.

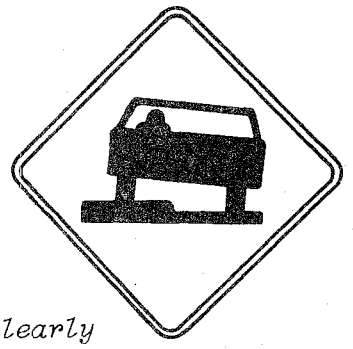
Some improvement in level of understanding was evidenced with the filmed approach to the ADVANCE FLAGGER symbol sign. In this case, 64 percent correctly identified the approach to a flagger. However, 24 percent indicated they would be watching for construction workers ahead, but not specifically for a flagger. The misinterpretation of a guarded school crossing was not as prevalent in the simulated driving situation - only four percent gave this response. A new interpretation was presented in the context of environmental cues that was not revealed in the slide portion of the survey. Four percent described the sign as meaning "stop". Although this sign looks nothing like a STOP sign, perhaps respondents perceived the flag signal displayed as one they should heed, or they were anticipating the necessity to stop ahead. Another interpretation of the sign was by one percent who said "hitchhikers in the area".

These misconceptions were incorporated into the questionnaire administered statewide, with similar results. Statewide, one percent thought the sign indicated hitchhikers in the area. Seventeen percent responded, "road construction ahead"; another 17 percent checked "guard

for school crossing"; and three percent said they did not know the meaning of the sign. Sixty-two percent correctly identified the representation of this sign.

Few background or attitudinal characteristics of the driving population explained differences in comprehension of the ADVANCE FLAGGER sign. Ethnic background was the only significant predictive factor.

In summary, the ADVANCE FLAGGER symbol sign is commonly given several interpretations. The most consistent problems were found to be: (1) recognition of a construction area, but lack of awareness of a person giving flag signals ahead; and (2) the incorrect definition of the sign as warning of a guard for a school crossing. On the basis of less than two-thirds correct interpretation, it is recommended that the ADVANCE FLAGGER symbol sign be accompanied by an educational plaque for clarity, in addition to distance messages.



2. LOW SHOULDER Symbol Sign

Structured Responses (percent correct)
63% - field survey
6% - slide survey

Symbol signs denoting uneven pavement should clearly delineate elevation differences, such as center versus shoulder, so that motorist can identify which lane has a lower elevation.

The LOW SHOULDER symbol sign is distinct from the UNEVEN LANES sign; however, it is most often confused with it. These two symbol signs are very similar in appearance, but have important differences in their messages.

Without alternatives provided, only six percent of those shown a slide correctly identified the LOW SHOULDER symbol sign. The majority of respondents (56 percent) thought the sign meant uneven pavement or uneven lanes. Thirty-seven percent of the responses were not related to the meaning of either sign. For instance, 11 percent thought the picture symbolized a bumpy road. Fourteen percent gave assorted incorrect answers, and 13 percent said they did not know what the sign meant.

When alternatives were provided in the booklet questionnaire, a much larger percentage could identify the LOW SHOULDER sign. In this case nine percent gave a "don't know" response and eight percent checked "bumpy road". Four percent said the sign signified a warning for stalled cars on the shoulder. Sixteen percent interpreted the sign as an indication of a hazard posed by a high curb. Finally, the LOW SHOULDER symbol sign was correctly identified by 63 percent of the drivers surveyed statewide.

A number of driver characteristics were associated with misinterpretation of the LOW SHOULDER symbol sign. Blacks, Hispanics, and other ethnic groups were more inclined than Anglos to misinterpret this sign. Age was also a significant variable, with more drivers in the oldest age group checking the "don't know" response. Although explanations were not obtained, drivers tested in Dallas were more knowledgeable of this sign, and drivers in Houston were most apt to misinterpret it. Finally, respondents with more years of driving experience were better able to correctly identify this sign's meaning.

The study showed that the LOW SHOULDER symbol sign is not an easy one for drivers to interpret. The large frequency that gave "don't know" responses is indicative of the vagueness of the symbol. Furthermore, associations with other hazards such as a high curb, bumpy road, or uneven lanes are obviously dangerous. Consider the consequences of a confused motorist who, believing the center of the roadway is uneven, compensates by staying very near and possibly going off a low shoulder. It is important for drivers to understand completely from automobile on pavement pictographs which surfaces to expect have elevation differences. This is not the case currently. Signs that are more direct and less likely to be misinterpreted should be used.

3. ADVANCE ROAD CONSTRUCTION Sign

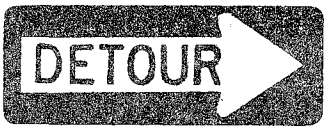
Unstructured Responses (percent correct)
100% - film survey
42%(color) } *shape and*
24%(shape) } *color test*

Well understood traffic control device.

The ADVANCE ROAD CONSTRUCTION sign was included in two of the survey approaches. First, the respondents' lack of knowledge of the shape and color code was demonstrated by their unfamiliarity with essential characteristics of this frequently used construction sign. Forty-two percent correctly identified its orange color, and 24 percent drew the appropriate diamond shape for warning signs. The sign was frequently described as being rectangular with a white background.

Respondents were shown a filmed approach to a sign with the message, "ROAD CONSTRUCTION AHEAD", and asked what their response would be if they were driving. Every respondent questioned was able to give a response that was an appropriate driving manuever. Each driver could identify and read the message presented in a real-time format. They also exhibited a thorough knowledge of what to expect and how to respond appropriately.

4. DETOUR ARROW Sign



Structured Responses (percent correct)
53% - field survey

Lack of motorist differentiation among DETOUR ARROW, ONE-WAY arrow, and LARGE ARROW turn signs. Informational strategies addressing color code of signs are warranted.

Three arrow signs were included in the study: the ONE-WAY arrow, the LARGE ARROW turn warning and the DETOUR arrow. All arrow signs were presented without their word messages for the purpose of determining drivers' ability to recognize and distinguish these signs on the basis of color. Although DETOUR arrows and ONE-WAY arrows always have the words displayed on the arrow, the LARGE ARROW turn sign has no written message. Even if their sizes and message content vary, an ability to immediately identify and react to each arrow may be facilitated by knowledge of the color code.

The orange arrow presented with no words was not familiar to 47 percent of the survey respondents. A significant number (21 percent) associated the orange arrow with one-way traffic. Only seven percent

confused it with a sharp turn warning arrow. Five percent said the arrow indicated a dead end, and the remaining 13 percent said they did not know what the arrow meant.

Two factors were discovered that had an influence in this case on knowledge of the color code. It was found that if the respondent drove on the job, they were much more likely to be aware of the orange DETOUR ARROW. The other positive influencing factor was to have taken driver education. For the most part, it can be said that drivers are not very familiar with the color code, as indicated by responses to arrow legends on signs.

OVERVIEW-CONSTRUCTION AND MAINTENANCE SIGNS

Traffic control devices that may be applied in maintenance and construction work zones are diverse, overlapping with legends used on other types of signs. However, the necessity for protective devices results in the development of signing that is uniquely designed for these situations. Only a sample of these signs were analyzed in this study.

Findings showed that a word legend is a much more effective communication than a pictograph symbol for construction areas. Symbol signs were often confused with similar symbols that have different meanings. Sometimes an association with construction was made, but the exact function of the sign was often missed. The surveys illuminated the fact that drivers are unaware of the shape and color code, especially concerning the use of orange for construction and maintenance areas.

Several driver characteristics were identified that seem to predispose confusion of construction symbol signs. Older drivers, blacks, Hispanics, and other minority ethnic groups were found to have more problems correctly identifying some of the signs. Conversely, motorists with many years of driving experience, those who had taken driver education, and employees who drive on the job showed a greater comprehension of the construction signs.

As pointed out above, the study was limited in its examination of construction and maintenance signing. The findings suggest that more in-depth study of the use of written messages versus symbols is needed. Additionally, efforts to inform the driving public of the use of orange for construction and maintenance signing should be undertaken.

Chapter VII. DRIVER UNDERSTANDING OF SERVICE, INFORMATION, AND GUIDE SIGNS.

One essential type of sign for vehicle operators along streets and highways is the guide sign. Green guide signs should be familiar to all drivers because of the frequency in which they are displayed. Of interest to the traveler, though not necessary for guidance, are messages that are conveyed on information signs. These signs call attention to services and recreational or cultural areas of interest. Five signs were included in the study to determine drivers' familiarity with guidance and informational signs.

1. Next Exit Supplemental Sign

Unstructured Responses
77% - correct shape
60% - correct color

Interpretation of the sign was not examined. Color and shape identification were high for the NEXT EXIT sign relative to all regulatory, warning, and other signs included in the shape and color survey.

NEXT EXIT supplemental signs are used on expressways and freeways in conjunction with an advance guide sign near an interchange. Its purpose is to inform the driver that failure to make a desired turn would require an additional number of miles out of the way. As a guide sign, its standard required shape is rectangular and its required color is green.

These characteristics were fairly familiar to the survey respondents, relative to the other 24 signs studied. Seventy-seven

percent drew the correct shape, and 60 percent knew the sign was green. Those who did not know the color most frequently thought it was white (18 percent). Another 10 percent identified the background color as blue.

2. Hiking Trail Symbol Sign

Structural Responses
21% - correct identification, slide survey

Poor recognition of sign by meaning and by color.

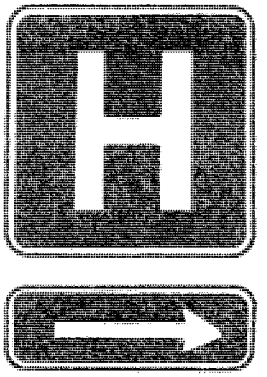
This informational sign marks an officially designated trail on a predetermined path to guide persons wishing to walk along that trail. In this sense, the sign is not oriented to all highway users; it is actually for the benefit of potential pedestrians. Because it is displayed on the roadway as guidance information to another traveling mode, this sign was included in the slide survey to determine if highway users understand its use, or if they confuse it with a required or advised driving maneuver.

Eleven percent of the respondents could not identify the HIKING TRAIL sign. Only 21 percent gave a correct identification of the sign. The majority (51 percent) made reference to the existence of campers or hikers, rather than a trail. This interpretation is not entirely correct - these responses were suggestions of hikers, campers, or pedestrians in the roadway that the motorist would be watching for.

A total lack of comprehension of the meaning of this sign as well as the color coding system was demonstrated by the four percent who

thought this sign meant "men working". The remaining responses (13 percent) were interpretations that did not fit into any category.

3. Hospital



I. Structured Responses (percent correct)
86% - field survey
68% - slide survey

II. Unstructured Responses
90% - film survey
35% (color) } *shape and*
70% (shape) } *color survey*

Little difficulty distinguishing the HOSPITAL sign in context.

In urban areas, and occasionally on conventional highways, it is desirable to call attention to the direction of a hospital. All service signs have white letters on a blue background.

It has become common practice to designate the direction of a hospital with a simple letter "H" in white on a blue panel, with a supplemental arrow for guidance. This practice was recognized by only 35 percent of the in-depth interview participants. Many (24 percent) thought the background color was white, and still others (17 percent) had no idea of the background color.

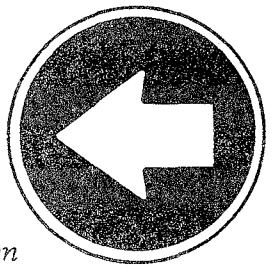
Part of the problem may be attributed to the respondents' lack of recognition of the meaning of this symbol sign. Sixty-eight percent recognized the sign in the slide survey, while 21 percent could give no interpretation for it. Other meanings assigned to the HOSPITAL sign were directions to a highway or freeway (given by four percent), hiking trail, detour, intersection, and underpass.

By the time the film was shown to the respondents, their recollection of the HOSPITAL symbol sign improved considerably. With the sign shown in context, 90 percent were able to explain its meaning. The miscellaneous interpretations that were given to the slide representation disappeared, and only correct responses or "don't know" admissions were given.

Alternative responses provided in the questionnaire booklet were: (1) Directions to a highway, (2) "H" intersection, (3) Hospital, (4) Underpass, and (5) Don't know. Eighty-six percent checked the correct response, six percent checked "don't know", and the remaining eight percent checked the other responses.

The findings suggest that drivers are not familiar with blue service information signs when out of context. However, in an actual driving environment, it is possible that, at least 90 percent of the drivers would have no difficulty distinguishing a HOSPITAL sign.

4. Texas Travel Trail Marker



Structured Responses (percent correct)
12% - slide survey

Low correct interpretation. Hazard posed only when drivers infer sign to require a driving response, as was the case for 39 percent of the respondents.

Trail Markers are informational plaques or shields designed to provide the traveling public with route guidance in following a trail of particular cultural, historical, or educational significance. These markers satisfy an information need on the part of certain travelers but

primary guidance should be in the form of printed literature and strip maps rather than highway signing (MUTCD 1978:2D-34).

In Texas there are 10 scenic and historical vehicular routes that are designated by trail markers. These markers have a very simple design - a white arrow on a circular blue background. As the mandate specifies, these markers provide a minimum amount of information that is pertinent only to certain drivers and no details are provided. In fact, there is no written message on or accompanying the sign that indicates a Texas Travel Trail.

The familiarity of Texas drivers with the Texas Travel Trails should determine the extent of knowledge of the Travel Trail Markers. One question of concern, however, is if drivers who are not seeking information concerning a travel trail mistakenly interpret this marker as a traffic control requiring a driver response. Thirty-nine percent of the in-depth interview respondents did define the Travel Trail Marker as a sign which requires or suggests a driving response. For example, 13 percent thought the sign required a right turn. Eleven percent said the sign was a one-way indication. Four percent responded "detour" and four percent responded "keep right".

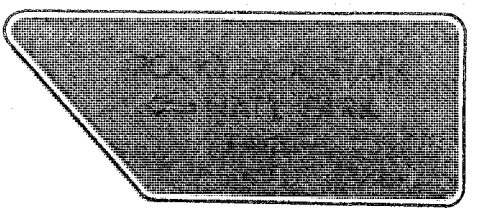
Respondents gave interpretations that were less oriented toward a necessary driving response, but were incorrect nevertheless. The most common of these was that the arrow showed directions to a hospital, believed by 12 percent. Several were more specific, suggesting the arrow was for hospital parking. A significant number (11 percent) gave the arrow a directional meaning of some kind, but not for a travel

trail. General information applications that were given were rest stop, park exit, evacuation route, first aid, and telephone.

Twenty-one percent of those interviewed could not give an interpretation for the Travel Trail Marker. On the other hand, 12 percent correctly identified the Texas Travel Trail Marker. Most of the respondents who could identify this marker were in the older, retired age group. The older drivers that were selected for in-depth interviewing were almost all from a retired senior citizen's volunteer organization. Their membership in this organization is suggestive of an activity level not inconsistent with travel. It is therefore conceivable that their use of leisure time and travel opportunities as retired persons make them more familiar with the Texas Travel Trails and their markers than other population segments.

In summary, the Texas Travel Trail Marker does not seem to be a critical sign for all motorists to understand because it only applies to those interested in the information it provides. However, it does become critical when it is interpreted as a traffic control device applicable to all and requiring a driving response, as it was by 39 percent of the survey respondents in this study. Fortunately, the sign is not a prominent one and there was evidence from the in-depth interviews that most people do not even perceive it as part of the signing system. This evidence may need to be documented more extensively, and if proved necessary, additional features added to the Travel Trail Marker so that is will be recognized as such.

5. Recreational Interest Area Signs



Responses (percent correct)
12% (correct color)
9% (correct shape)

Physical characteristics of these little used signs are not known by Texas motorists.

Occasionally recreational or cultural interest areas are a significant destination on a numbered highway route. In these instances they are marked at the point at which the area's access road intersects the highway. The primary or supplemental sign used may be either rectangular or trapezoidal in shape, and has, white letters on a brown background. These signs are straightforward and self-explanatory. They are simply place names and a directional arrow.

An example of a recreational interest area sign was included in the survey to see how aware Texas motorists are of the unique shape and color coding of these signs. It was discovered that only 12 percent of the drivers knew that these signs are brown. One-third of the respondents recalled recreational signs being green. Another 23 percent said they have white backgrounds.

Concerning shape, the overwhelming majority (83 percent) gave the Rocky Mountain National Park directional sign a rectangular shape. While this is not incorrect, the revealing fact was that no one gave the sign a trapezoidal shape. It is therefore concluded that, as was found with other categories of signs, the shape and color coding system escapes most Texas drivers. Recreational interest area signs are not common on Texas roadways, relative to other types of signs. Not

surprisingly, their physical characteristics are not frequently recalled by the driving public.

OVERVIEW-SERVICE, INFORMATION, AND GUIDE SIGNS

Service, Information, and Guide signs were included in the study on a somewhat limited basis relative to other traffic controls. The information obtained concerning these miscellaneous signs revealed at least one generalizable fact. The majority of Texas drivers are not aware of the colors used to designate services, general information, or recreation areas. They are more knowledgeable of the use of green for guide signs. At times this lack of information concerning color has the potential to result in hazardous situations. Specifically, some drivers interpret signs intended for certain drivers (who are desirous of the information displayed) as applicable to all and requiring action. This confusion is partially a result of incomplete knowledge of the use of color to ferret out necessary from additional useful (but not necessary) information.

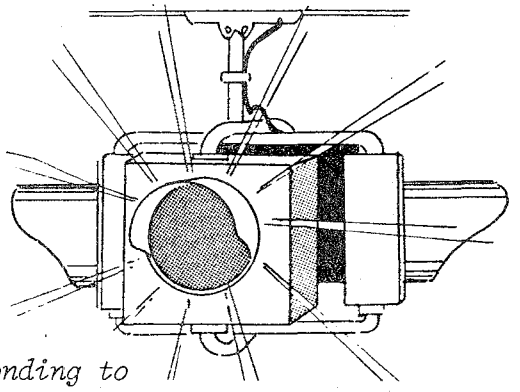
Chapter VIII. DRIVER UNDERSTANDING OF TRAFFIC SIGNALS

Traffic signals control traffic movement in terms of alternate stopping and permission to proceed. It is essential that uniformity is found for all traffic control signals and that motorists understand their usage. Features of traffic control signals affecting driver understanding are:

- Knowledge of color indications
- Recognition of related environmental cues, including other traffic controls
- Location and uniformity of location of signals
- Design aspects of signals

Licensed drivers are well-versed in the meanings of green, yellow, and red signal indications. However, there are many combinations and variations of these three signals. New roadway designs and more complex vehicular movement requirements (such as time restricted lane use) have led to recent developments in signalization that differ from the simple green, yellow, and red circular signals. It cannot be assumed that appropriate responses to signals are innate in the driving public. Noncompliance may be seen not only in the form of disregard, but also in the form of confusion and misunderstanding. Six signal indications were included in this study to investigate level of comprehension of signals among Texas drivers.

1. Yellow Beacon/Flashing Mode



I. Structured Responses (percent correct)
54% - field survey
84% - slide survey
II. Unstructured Responses
98% - film survey

From structured responses, it appears that respondents may be overly cautious in responding to the YELLOW BEACON.

A flashing yellow beacon is a caution signal. Drivers of vehicles may proceed through an intersection or past such a signal only with caution. Drivers were asked what they should do upon seeing this type of signal as they viewed an example on film.

There were four groups of responses, three that can be considered correct to some degree. The one response given that was incorrect was "stop" (given by one percent). The other three types of responses consisted of "slow down", "use caution," and combinations of both.

Taking each of these separately, 27 percent of the respondents said "slow down". Forty-nine percent answered "use caution", and 22 percent gave responses that included both "slow down" and "use caution", and several of these respondents also included "look for cars coming". Perhaps these responses are not distinct enough to warrant separate classifications, yet these answers are predictive of the driving task perceived to be correct by respondents.

Additional information was obtained that indicated responsiveness to the yellow flashing beacon. Laboratory in-depth interview participants who viewed the film were asked if they knew what color signal intersecting traffic would see and what the intersecting traffic should be doing. Eighty-four percent of the respondents knew that

intersecting traffic would have a red indication. Only nineteen percent recognized that this red would also be in a flashing mode. Three percent assumed intersecting traffic would have a flashing yellow indication also. Other combinations included steady yellow (four percent), either red or green (two percent), and either red or yellow (two percent). Also, two percent did not know what signal indication color intersecting traffic would see.

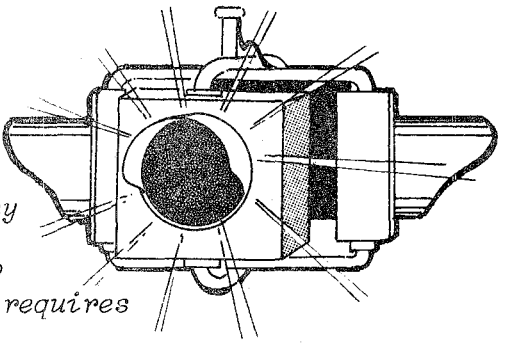
This question was presented to survey participants in the six driver licensing stations: "at an intersection, the yellow light is flashing on and off. What type of light would intersecting traffic see?" When presented with alternatives, the correct response was not so clearly established. Slightly more than half (54 percent) answered correctly, flashing red. Thirty-eight percent thought intersecting traffic would see flashing yellow. Other responses were "steady red" (three percent), "steady yellow" (two percent), and "don't know" (two percent).

Considering the implications of this confusion regarding intersection light color, in one respect the consequences do not seem severe. If motorists are approaching what they know to be a caution light, and expect that traffic approaching to their right or left also has a caution light, they are much more likely to be prepared to stop. However, this may also be a hazardous situation that increases the likelihood of a rear-end collision.

Among background characteristics which explained level of understanding, language was a critical variable for comprehension of the

beacon's meaning and use. Respondents whose primary language was English more often stated that adjacent traffic would see flashing red.

There was some evidence that this knowledge is acquired from driving experience. Newly licensed drivers and those with fewer years of experience were not as knowledgeable as others. Another positively related factor was the completion of a driver education course.



2. Red Beacon/Flashing Mode

87% Correct Response on Field Survey

Recommendation that efforts be considered to instruct drivers that a flashing red signal requires motorists to stop.

Drivers in the six driver licensing stations were asked the following question pertaining to a red flashing beacon:

"At this intersection, the red light is flashing on and off. What should you do?"

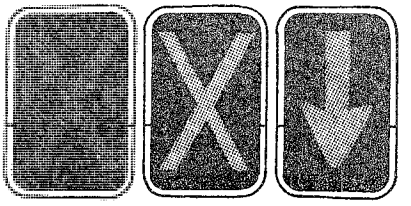
The responses provided were:

1. Be prepared to stop for a train
2. Slow down and look both ways before entering intersection
3. Come to a rolling stop, then proceed if clear
4. Come to a full stop, then proceed when clear
5. Don't know

The fourth response was checked by 87 percent of the respondents. These people tended to be Anglos who had taken driver education and were not newly licensed.

Only one percent checked the "don't know" response. Six and five percent, respectively, checked the third and second response. This is perhaps an indication that the flashing mode has a diminishing effect for some drivers. Thus, eleven percent stated that precautionary driving meneuvers were warranted, and did not realize the full prohibitive feature of this signal. It is recommended that effects be considered to instruct drivers that a red flashing signal means stop.

3. Lane-Use Control Signals



51% Correct Response on Film Survey for RED X
55% Correct Response on Film Survey for DOWNWARD GREEN ARROW

Findings reinforce the need for the supplementary signs that explain the meaning of each control.

Lane-use control signals prohibit or permit the use of designated lanes. They are used in four types of situations, most commonly for reversible-lane control. The indications used have consistent meanings; however, supplementary signs are often used to explain their meaning and intent.

Interviewees were questioned regarding the meaning of indications used for reversed lanes. The respondents were all residents of a metropolitan area where no reversible-lane operations are or have been in use. They were shown a film segment that featured four lanes. Three signals displayed steady DOWNWARD GREEN ARROWS and one signal displayed a steady RED X. Respondents were given instructions that these signals were not placed at intersections.

The MUTCD very succinctly defines these two indications.

(1). A steady DOWNWARD GREEN ARROW means that a driver is permitted to drive in the lane over which the arrow signal is located.

(2). A steady RED X means that a driver shall not drive in the lane over which the signal is located, and that this indication shall modify accordingly the meaning of all other traffic controls present.

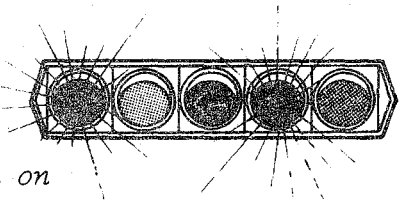
The study particpants were able to define the meaning of the DOWNWARD GREEN ARROW much better than the RED X. They gave a variety of interpretations of the RED X indication, only 51 percent of which were correct. Ten percent could not provide an interpretation for the RED X. Other responses were "stop", yield", "lane ends," "vehicles may not turn," and "the light is out."

A significant number of respondents (42 percent) associated the DOWNWARD GREEN ARROW with directional information instead of permission for lane use. Fifty-five percent demonstrated a working knowledge of this signal. The remaining three percent either did not know what the DOWNWARD GREEN ARROW indicated (two percent), or identified it as a signal for a tunnel (one percent).

It should be reported that although this traffic control device was presented by means of an intended simulated driving context, this particular signal was not readily visible in the film survey. It was necessary to show closeups of the signal indication to insure its visibility. Consequently, much of the environmental surroundings were omitted from the film segment. Respondents gave their responses based on spontaneous interpretations of the signal faces, and had little opportunity to assess other features in the environment. In one

respect, this is a more accurate measurement of the public's understanding of these indications. However, the prolonged presence of other cues possibly could have increased the accuracy of responses.

4. Combination Signal Indications



A. CIRCULAR GREEN/GREEN ARROW
98% correct identification on slide survey

B. CIRCULAR RED/GREEN ARROW
60% correct identification on field survey

C. CIRCULAR RED/YELLOW ARROW
64% correct identification on field survey

Based on the field survey results, auxiliary sign, "Protected Left Turn," should accompany turn signals that have simultaneous display of contradictory colors.

There are three basic displays used in signal operations: circular red, circular yellow, and circular green. These are often accompanied by arrow indications which are displayed simultaneously. Three signal face combinations of circular and arrow indications were presented to Texas drivers to measure their level of comprehension regarding appropriate driving maneuvers specific to arrow signals.

a. CIRCULAR GREEN/GREEN ARROW

Respondents were shown a slide of a green left turn arrow combined with a circular green indication on the same signal face, and asked what the green arrow meant. Ninety-eight percent of the respondents knew that the combined green arrow with circular green indication meant that a left turn would be protected.

b. CIRCULAR RED/GREEN ARROW

A confusing signal for motorists is one in which ARROW indications seemingly contradict circular indications. An example is the green arrow displayed simultaneously with a circular red indication. The arrow is displayed for vehicles in an exclusive left turn lane, and the circular red indication is for through traffic. However, many motorists in the turn lane react as if both indications are applicable to their movement, in spite of separate signal faces for through traffic.

This confusion was demonstrated by the fact that 31 percent of the 364 questionnaire respondents considered the appropriate action to be "stop first, make sure not one is coming, then turn left." Another five percent said they would "wait to turn until the red light turns green." Others who would stop at an intersection with a signal face displaying both a green arrow and a circular red light were those four percent who said they would assume such a signal to be broken.

The potential for conflict exists when 60 percent of the drivers surveyed answered "turn left because you have a protected turn." When 40 percent of the driving population believes a red circular/green arrow combination means stop, and 60 percent believes it means to proceed to turn with protection, the potential for rear-end collisions is greatly increased.

Drivers' conceptual improvement was not evidenced in the survey situation where they were able to observe other cars, other lanes, and the locational aspects of the signal display. In fact, only 55 percent recognized the indication of a protected left turn. The remaining 45 percent assumed that stopping would be required or necessary.

The results reveal that contradictory lense colors, green and red, require additional information for the motorist to proceed without confusion. A message that indicates to the driver that the arrow indication is to instruct turning traffic of a protected turn and that circular indications are for through traffic, should be placed where simultaneous contradictory lense color indications are displayed.

c. CIRCULAR RED/YELLOW ARROW

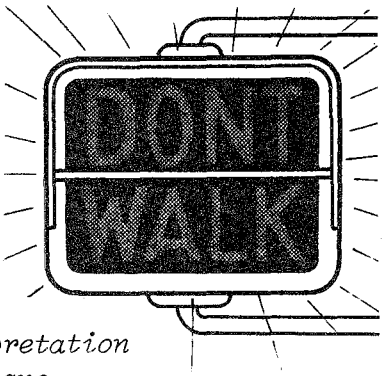
> You are about to enter an intersection and the signal has a yellow left turn arrow and red light both on. You are in the left turn lane. What do you do?

This question was posed to participants in the statewide survey. A picture of the signal was also presented for their examination. Indecision concerning what to do revolved around the same type of confusion associated with the GREEN ARROW combined with the CIRCULAR RED indication. The decision is whether to stop or go, but the problem lies not in any ambiguity of the color yellow. The problem in this case is the combination with the CIRCULAR RED indication. This is illustrated by the fact that 21 percent of the respondents said they would "stop, then proceed with caution." Additionally, 13 percent thought the appropriate action would be to "stop, and then turn when no cars are coming." Therefore, 34 percent of the motorists surveyed would continue to turn after stopping first.

The remaining 64 percent made choices that are consistent with decisions that should be made regarding a cautionary turn indication. Forty-six percent decided to stop and wait for a green arrow, and 18 percent stated they would make the turn quickly, with caution. Either

of these responses can be considered acceptable, depending upon the respondent's perceived position relative to the intersection.

The hazard posed by the yellow arrow displayed simultaneously with the red circular indication is the likelihood of head-on collisions caused by drivers proceeding to turn after stopping. As pointed out in the CIRCULAR RED/GREEN ARROW discussion above, contradictory lense colors result in confusion when displayed on the same signal face. For the same reasons, it is recommended that efforts to educate the driving population on the appropriate responses to arrow indications be undertaken.



5. Pedestrian Signal Indications

Structured Responses (percent correct)
85% - field survey
65% - slide survey

Hazard posed by one type of incorrect interpretation - pedestrians who would stop at the center lane marking or roadway center without a median.

There are two lense indications on pedestrian signals with the illuminated words WALK and DONT WALK. There is no doubt that these commands are direct and very simple to understand. However, there is a third message that is directed to pedestrians that is not understood, i.e., DONT WALK in a flashing mode. According to the MUTCD (4D-1), "The DONT WALK Indication, while flashing, means that a pedestrian shall not start to cross the roadway in the direction of the indication, but that any pedestrian who has partly completed his crossing during the

steady or flashing WALK indication shall proceed to a sidewalk, or to a safety island."

In the previous study by Koppa, et al. (1978), only 42 percent of all survey respondents indicated a correct understanding of the flashing DONT WALK signal indication. The majority were familiar with the pedestrian signal, but were overly cautious in their interpretation of the flashing mode, suggesting the need to return to the curb or wait in the center of the street.

These findings were replicated somewhat in the current study. Eighty-five percent of the 94 survey participants who were questioned concerning a flashing DONT WALK signal indication stated it meant not to cross the street. When more detailed options were provided in the questionnaire booklet, only 65 percent knew that it would be safe to quickly cross to the other side of the street, if the curb has been left when the DONT WALK indication begins to flash. Ten percent stated they would go back to the curb they just left. Twenty-four percent perceived that the flashing indication meant they should stop at a midpoint in the street (14 percent checked at the center marking, 11 percent checked "halfway" without knowing the type of roadway center). The latter two response sets place pedestrians in a vulnerable position.

Knowledge of the meaning of a flashing DONT WALK indication was correlated with three of the basic background characteristics - age, education, and ethnicity. The groups isolated as having problems were the older respondents, the lower educated, and ethnic minorities.

When pedestrian signals are used, there is always a pedestrian clearance interval (the flashing DONT WALK indication). Duration of

this indication is calculated by the width of the roadway and allowing for a normal walking speed of four feet per second.

On streets with a median at least six feet wide, often there is only enough time allowed for pedestrians to clear the crossing from the curb to the median. An assessment should be made by the pedestrian at the onset of a flashing signal, whether to continue to an existing median or to increase walking pace to cross. Although retreating to the curb just left does not pose a serious problem for either pedestrian or motorist, stopping midway with no median does pose a problem for both.

One conclusion that can be drawn from the two survey approaches undertaken in this study is that pedestrians do in fact tend to interpret the flashing DONT WALK indication over-cautiously. This conclusion is based on the 85 percent who said DONT WALK In the unstructured interview format. Only when respondents were presented with other options did they waver in their decisions. One recommendation that can be made regarding those who may stop at a midpoint with no median is that this factor be taken into account so that the clearance phase allows ample time to clear the crossing. Another recommendation that initially may be very costly but would provide the optimum communicative feature would be a three phase, three color pedestrian signal. In other words, a yellow caution phase, consistent with other traffic signals, would more accurately convey the clearance message.

SUMMARY OF TRAFFIC SIGNALS

Misunderstanding, confusion, or ignorance of the meaning of traffic

signal indications cause a range of problems in the orderly and predictable movement of traffic. Problems that range from the aggravation caused by a vehicle stopped at a GREEN ARROW/CIRCULAR RED indication or a flashing YELLOW BEACON, to the fatal consequences of a pedestrian struck at the center stripe of a roadway, or a major collision on a rural highway at a flashing RED BEACON may often be attributed to lack of knowledge of signal indications. This chapter documents several misinterpreted traffic signals.

Flashing beacons represent a problem for many motorists because they do not know what to expect from intersecting traffic. Additionally, there was evidence that the full effect of the RED BEACON is diminished somewhat by its flashing mode. It is recommended that countermeasures be developed that give instructions to drivers. For example, a sign similar to that used at a multiway stop intersection might be used to give information about intersecting traffic.

The study showed that only about half of the respondents fully comprehended LANE-USE CONTROL SIGNAL indications. This has the potential for difficulties when immediate response is necessary. It is therefore recommended that supplemtary signs always be used to explain the meaning and intent of these indications.

Certain combinations of signal indications on the same signal face were found to be confusing to a significant number of Texas motorists. Specifically, arrow and circular indications of contradictory colors resulted in indecision on the part of the respondents as to which indication to obey or if a combination of maneuvers was indicated. This problem can be lessened by the use of additional information plaques

on-site, and by educational efforts to clarify the appropriate responses to arrow indications.

One pedestrian signal indication was examined - the flashing DONT WALK clearance phase. It was determined that the tendency is toward an overly cautious interpretation of the clearance phase. With no prompting, 85 percent of the respondents considered a flashing pedestrian signal to mean DONT WALK. A potentially hazardous situation was exposed in the statewide survey from the 24 percent who suggested they would stop at a midpoint in the roadway in response to the flashing signal. If no median exists, it is recommended that the clearance phase be timed long enough to allow for this type of misunderstanding.

IX. ESTABLISHMENT OF CRITICALITY RANKINGS FOR MISUNDERSTOOD TRAFFIC CONTROL DEVICES

With the difficulty many motorists evidence in correctly identifying various signs, signals, and pavement markings, a need exists to determine the hazard posed by misunderstanding specific traffic controls. If five percent of the driving public, for example, incorrectly identify the one-way traffic regulatory sign, the accident potential is much greater than if 95 percent of the state's drivers are unable to identify the Texas Travel Trail marker. For this reason, a technique for determining the criticality of individual traffic control devices is warranted.

Previously, traffic engineers, as well as researchers, have relied on their intuitive judgments to determine the criticality attached to many problematic traffic controls. A variation on this approach is the Delphi method which has been developed to use experts, in this case, traffic engineers, law enforcement personnel, traffic safety educators, and transportation researchers, to provide criticality ranks. The method is designed to make effective use of informed judgment. Delphi provides a means of seeking group consensus which avoids some of the problems of face-to-face confrontation that many times characterizes a group decision making process.

The Delphi panel was created to evaluate hazards posed by driver misunderstanding of traffic controls. Twenty-three knowledgeable traffic-related personnel were asked to particpate in the Delphi sequence. In "Round One," the 23 panelists were given renderings of 50

traffic controls and were requested to sort them into five categories, by order of hazard posed, if drivers misunderstood these devices.

The categorizing of traffic controls ranged from a "1," indicating "No Potential Hazard Posed by Drivers Misunderstanding This Traffic Control" to a "5," indicating a "Severe Hazard Posed by Misunderstanding This Traffic Control." The majority of traffic controls were ranked as potentially hazardous, with 10 out of 50 receiving a mean rank of 4.0 to 4.9 and 26 a mean rank of 3.0 to 3.9. Researchers and traffic safety educators tended to provide higher criticality ranks than did law enforcement officials or traffic and human factors engineers.

For "Round Two" of the Delphi sequence, each respondent received a computer print-out of his/her original ranks for each traffic control, as well as the mean rank and standard deviation for all Delphi panelists. As shown in Figure 4, the expert was requested to either provide a rationale for, or alter, ranks that deviated more than 1.75 from the mean rank. In addition, the ranks of any other traffic controls not singled out because of deviation from the mean criticality rank could be altered. The number of deviations starred because they represented "outliers" ranged from 0 to 10.

Figure 4 provides an example of a traffic engineer's rankings, two of which were starred (the "No Passing Zone" warning sign and the "Dashed White" pavement markings). For the "No Passing Zone" sign, this panelist kept his original rank and provided a rationale behind his assessment. In the second case, the expert altered his rank to conform more closely to the mean rank of the panel.

Figure 4. Example of Round Two: Delphi Panelist Response to Mean Criticality Ranks

DELPHI PANEL ROUND 2 — ENGINEER

(COLUMN 1) NAME OF TRAFFIC CONTROL DEVICE	(COLUMN 2) MEAN CRITICALITY RANK (N=23)	(COLUMN 3) STANDARD DEVIATION FROM MEAN (N=23)	(COLUMN 4) CRITICALITY RANK	(COLUMN 5) IF YOU WISH TO CHANGE YOUR RANK ON ANY TRAFFIC CONTROL DEVICE, YOU MAY DO SO NOW IN THE SPACES BELOW. RANKS MUST RANGE FROM 1 TO 5, WITH 1=LEAST HAZARDOUS AND 5=MOST HAZARDOUS	(COLUMN 6) IF YOUR RANK ON EACH TRAFFIC CONTROL DEVIATES MORE THAN 1.75 FROM THE MEAN RANK, IT WILL BE STARRED (*). YOU MUST EITHER ARGUE TO KEEP THIS STARRED RANK IN THE SPACE PROVIDED BELOW OR CHANGE THE RANK IN THE SPACE PROVIDED IN COLUMN 5 FOR THIS TRAFFIC CONTROL DEVICE.
REGULATORY SIGNS					
DO NOT ENTER	4.83	0.388	5		
YIELD TO TRAFFIC IN CENTER LANE	3.48	1.123	2		
STOP SIGN	4.83	0.388	5		
YIELD SIGN	4.43	0.590	5		
TWO - WAY LEFT TURN ONLY (DUAL TURN)	3.26	1.010	3		
ONE - WAY	4.26	0.752	5		
NO RIGHT TURN	3.96	0.767	4		
DOUBLE TURN	3.35	0.832	2		
KEEP RIGHT	3.61	1.033	4		
CLIMBING LANE AHEAD	1.61	0.722	2		
WARNING SIGNS					
NO PASSING ZONE	4.00	1.000	2 *		As long as the driver properly understands the no-passing zone pavement marking, misunderstanding ~~the no-passing zone warning sign would~~ have little consequence. The no-passing zone warning signs merely serve to give some advance notice of where a no-passing zone begins, assuming drivers can see the sign sooner than the pavement markings. A prudent driver, properly interpreting other devices, could drive safely without no-passing zone warning signs. If the device is unnecessary, I fail to see a likely misinterpretation that would be very hazardous.
TWO - WAY TRAFFIC	4.17	0.717	4		
SCHOOL CROSSWALK CROSSROAD	3.74	0.689	3		
INTERSECTION	3.13	1.058	3		
SHARP TURN ARROW PAVEMENT	4.17	0.834	4		
LANE TRANSITION LEFT / RIGHT	3.30	0.703	4		
TURN SIGN	3.91	0.956	3		
PAVEMENT ENDS	3.00	1.044	3		
PEDESTRIAN CROSSING	3.65	0.714	3		
ROADWAY ALIGNMENT SCHOOL ADVANCE	3.39	1.076	4		
(SCHOOL ZONE)	2.91	0.848	3		
SLIPPERY WHEN WET	3.09	0.596	3		

Figure 4 - Continued

DELPHI PANEL ROUND 2				ENGINEER	
(COLUMN 1) NAME OF TRAFFIC CONTROL DEVICE	(COLUMN 2) MEAN CRITICALITY RANK (N=23)	(COLUMN 3) STANDARD DEVIATION FROM MEAN (N=23)	(COLUMN 4) CRITICALITY RANK	(COLUMN 5) IF YOU WISH TO CHANGE YOUR RANK ON ANY TRAFFIC CONTROL DEVICE, YOU MAY DO SO NOW IN THE SPACES BELOW. RANKS MUST RANGE FROM 1 TO 5, WITH 1=LEAST HAZARDOUS AND 5=MOST HAZARDOUS	(COLUMN 6) IF YOUR RANK ON EACH TRAFFIC CONTROL DEVIATES MORE THAN 1.75 FROM THE MEAN RANK, IT WILL BE STARRED (*). YOU MUST EITHER ARGUE TO KEEP THIS STARRED RANK IN THE SPACE PROVIDED BELOW OR CHANGE THE RANK IN THE SPACE PROVIDED IN COLUMN 5 FOR THIS TRAFFIC CONTROL DEVICE.
LEFT / RIGHT CURVE SIGN	3.35	0.985	3		
STOP SIGN AHEAD	2.96	0.638	3		
RAILROAD ADVANCE WARNING	3.22	0.951	3		
MERGE SIGN	3.26	1.010	3		
DEER CROSSING	1.83	0.388	2		
RIDE STATION	1.87	0.548	2		
SIGNAL LIGHT AHEAD	2.83	0.778	3		
DIVIDED HIGHWAY	3.26	0.915	4		
SOFT SHOULDER	2.48	0.947	1		
CONSTRUCTION SIGNS					
LOW SHOULDER	3.17	0.717	3		
CURVE AHEAD	3.35	1.071	2		
FLAGMAN AHEAD	3.22	0.736	4		
GUIDE / DIRECTIONAL SIGNS					
HOSPITAL	1.26	0.449	1		
HIKING TRAIL	1.26	0.449	1		
PAVEMENT MARKINGS					
DASHED YELLOW WITH SINGLE SOLID YELLOW	4.13	1.140	5		
DASHED YELLOW	3.78	1.043	4		
DOUBLE SOLID YELLOW TWO - WAY (DUAL)	4.48	0.665	4		
LEFT TURN STORING	3.61	0.783	3		
SOLID WHITE	2.78	1.126	3		
DASHED WHITE	2.96	1.522	1 *	2	

Figure 4 - Continued

DELPHI PANEL ROUND 2 ENGINEER

(COLUMN 1) NAME OF TRAFFIC CONTROL DEVICE	(COLUMN 2) MEAN CRITICALITY RANK (N=23)	(COLUMN 3) STANDARD DEVIATION FROM MEAN (N=23)	(COLUMN 4) CRITICALITY RANK	(COLUMN 5) IF YOU WISH TO CHANGE YOUR RANK ON ANY TRAFFIC CONTROL DEVICE, YOU MAY DO SO NOW IN THE SPACES BELOW. RANKS MUST RANGE FROM 1 TO 5, WITH 1=LEAST HAZARDOUS AND 5=MOST HAZARDOUS	(COLUMN 6) IF YOUR RANK ON EACH TRAFFIC CONTROL DEVIATES MORE THAN 1.75 FROM THE MEAN RANK, IT WILL BE STARRED (*). YOU MUST EITHER ARGUE TO KEEP THIS STARRED RANK IN THE SPACE PROVIDED BELOW OR CHANGE THE RANK IN THE SPACE PROVIDED IN COLUMN 5 FOR THIS TRAFFIC CONTROL DEVICE.
SIGNALS					
FLASHING RED BEACON	4.52	0.393	5	___	
AMBER LEFT TURN ARROW	3.17	1.114	4	___	
FLASHING AMBER BEACON	3.09	1.164	2	___	
PEDESTRIAN "DON'T WALK" (FLASHING MODE)	3.30	1.146	2	___	
GREEN LEFT TURN ARROW (WITH RED LIGHT)	2.70	0.926	2	___	
OBJECT MARKERS / BARRICADES					
TYPE III OBJECT MARKER	2.35	1.027	2	___	
TYPE VI OBJECT MARKER	2.87	1.424	4	___	
TYPE III (C) BARRICADE	3.09	1.240	4	___	
OVERALL MEAN	3.28		3.12		

THANK YOU FOR YOUR COOPERATION.

When "Round Two" results were tabulated, there were fewer "outliers" and the standard deviations for each traffic control were significantly reduced. The Delphi sequence made it possible to obtain many of the advantages of utilizing a group of experts while eliminating many of the disadvantages of a group setting. The procedure was characterized by (1) anonymity; (2) iteration and controlled feedback; and (3) statistical responses for the group.

Table 7 displays the rankings of traffic controls in statistically significant clusters, using Duncan's multiple range test. The "A" group for example, points to mean ranks that cluster so closely as to be significantly different from the remaining clusters. The "A" group points to the most critical hazards posed through incorrect identification, with the "Q" group depicting those traffic controls perceived by panelists to present no real hazard. Based on the interests and needs of decision makers, only the first or the top few criticality clusters should be utilized to distinguish target traffic controls for countermeasures. In this case, any criticality ranking over the overall mean rank of 3.3 was selected for comparison with the laboratory interviews and field survey responses.

To link the ranks in Table 7 with the percent incorrectly identifying traffic controls, arbitrary tipping points were derived: any traffic control device in Groups A, B, or C was considered nonproblematic if over 90 percent identified it accurately in at least one of the four testing situations. The rationale for this tipping point was that even a fraction of the respondents incorrectly identifying traffic controls where high potential hazards exist, i.e.,

Table 7. Ranking of Criticality of Traffic Controls

Traffic Control Device	Mean Rank	Multiple Range Clustering
1. Do not enter symbol sign	4.83	A
2. Stop sign	4.83	A
3. Double solid yellow center marking	4.52	AB
4. Red beacon (flashing)	4.52	AB
5. Yield sign	4.43	ABC
6. Broken and solid yellow line combinations	4.43	ABC
7. One-way traffic symbol sign	4.30	ABC
8. Two-way traffic symbol sign	4.17	BCD
9. Large arrow (sharp turn) sign	4.17	BCD
10. No passing zone pennant	4.04	BCDE
11. Broken yellow center marking	3.96	BCDEF
12. No right turn symbol sign	3.91	CDEFG
13. Left/right turn symbol sign	3.91	CDEFG
14. School crossing symbol sign	3.74	DEFGH
15. Pedestrian crossing symbol sign	3.65	DEFGHI
16. Keep right symbol sign	3.61	DEFGHI
17. Yield to traffic in center lane sign	3.56	EFGHIJ
18. Two-way left turn pavement markings	3.56	EFGHIJ
19. Chevron alignment sign	3.48	EFGHIJK
20. Detour arrow sign	3.43	FGHIJK
21. Pedestrian "Don't Walk" (flashing mode)	3.43	FGHIJK
22. Double turn symbol sign	3.35	GHIJKL
23. Left/right curve sign	3.35	GHIJKL
----------3.30 = Overall Mean Criticality Rank ----------		
24. Pavement width transition sign	3.30	HIJKL
25. Merge symbol sign	3.30	HIJKL
26. Two-way left turn only symbol sign	3.26	HIJKLM
27. Divided highway symbol sign	3.26	HIJKLM
28. Flagger ahead warning symbol sign	3.22	HIJKLM
29. Cross road symbol sign	3.17	HIJKLM
30. Amber left turn arrow signal	3.17	HIJKLM
31. Low shoulder symbol sign	3.13	IJKLM
32. Slippery when wet symbol sign	3.09	IJKLM
33. Railroad advance warning symbol sign	3.09	IJKLM
34. Type III (c) barricade	3.09	IJKLM
35. Broken white center marking	3.00	JKLMN
36. Yellow beacon (flashing)	3.00	JKLMN
37. Type VI marker	3.00	JKLMN
38. School advance symbol sign	2.96	KLMN
39. Stop sign ahead symbol sign	2.96	KLMN
40. Pavement ends sign	2.91	KLMNO
41. Solid white line	2.91	KLMNO
42. Signal light ahead symbol sign	2.83	LMNO
43. Green left turn arrow (with red light) signal	2.70	MNO
44. Soft shoulder sign	2.48	NO
45. Type III object marker (vertical)	2.39	O
46. Fire station symbol sign	1.87	P
47. Deer crossing symbol sign	1.83	P
48. Climbing lane ahead sign	1.70	PQ
49. Hospital symbol sign	1.26	Q
50. Hiking trail symbol sign	1.26	Q

ranks greater than 3.9 and less than 5.0, should be isolated as candidates for countermeasures.

The following 11 traffic controls in Groups A, B, and C were incorrectly identified by at least 10 percent of the driving public:

- DO NOT ENTER sign (symbol-no verbal message)
- STOP sign (symbol-no verbal message)
- DOUBLE SOLID YELLOW CENTER MARKING
- RED BEACON (flashing)
- YIELD sign
- ONE-WAY TRAFFIC SYMBOL sign
- LARGE ARROW (sharp turn) sign
- NO PASSING ZONE pennant
- BROKEN YELLOW PAVEMENT MARKING
- PROHIBITED RIGHT TURN symbol sign
- RIGHT/LEFT TURN arrow

Those controls in Groups A,B, and C correctly identified by more than 90 percent of the respondents were (1) the SOLID/BROKEN YELLOW PAVEMENT MARKING and (2) the TWO-WAY TRAFFIC warning sign.

If over 80 percent of the respondents identified a traffic control in groups D, E, F, and G correctly, then this device was deleted for application of educational strategies. The mean ranks in these four groups ranged from over 3.3 to 3.9. Using this criteria, the following eight traffic controls were selected from Group D, E, F, and G for consideration of countermeasures.

- SCHOOL CROSSING sign
- KEEP RIGHT symbol sign

- YIELD TO TRAFFIC IN CENTER LANE sign[1]
- TWO-WAY LEFT TURN pavement markings
- CHEVRON ALIGNMENT sign
- DETOUR ARROW sign
- PEDESTRIAN "DONT WALK" signal (flashing mode)
- DOUBLE TURN symbol sign

Traffic controls from Groups C, D, E, and F correctly identified by more than 80 percent of the respondents were (1) the PEDESTRIAN CROSSWALK and (2) the LEFT/RIGHT CURVE symbol sign.

Table 8 shows the 19 traffic controls selected from the 23 controls in Groups A through G. Mean rankings and primary misconceptions are presented.

Other traffic controls not receiving high criticality ranks, but representing controls not easily identified by the driving public are shown in Table 9. The signs, pavement markings, and signals in Table 9 were correctly interpreted by less than 50 percent of the driving public.

[1]YIELD TO TRAFFIC IN CENTER LANE is no longer recommended for use in the Texas MUTCD (1980). However, it remains on roadways as a part of the traffic communication system. Warranted countermeasures include removal of this sign and discontinuing placement (see Chapter IV).

Table 8. Targeted Traffic Control Devices Posing Hazards if Misunderstood by Driving Public (Criticality Ranks > Overall Mean of 3.3) by Mean Ranks and Primary Misconception

Traffic Control Device	Mean Criticality Rank	Primary Form of Misunderstanding
Regulatory Signs		
1. Do Not Enter Symbol Sign (no verbal message)	4.83	65% unfamiliar with symbol meaning. Large "don't know" response - 34%, typically by those without driver education training.
2. Stop Sign (no verbal message)	4.83	Recognized by less than 80% of drivers by shape and color; the word 'STOP' must be visible to be identified.
3. YIELD (no verbal message)	4.43	Recall of physical appearance very low. Recognized by less than 90% by shape and color.
4. One-Way Traffic (no verbal message)	4.30	Confusion primarily with DETOUR arrow sign. Lack of awareness of white/black regulatory color code.
5. Prohibited Right Turn	3.91	Prohibitory meaning of red slashed circle understood by less than 70% of drivers. 7% interpreted mandatory right turn rather than prohibitory.
6. Keep Right	3.61	Confused with DIVIDED HIGHWAY symbol sign.
7. Yield to Traffic in Center Lane	3.56	Drivers understand to give center lane right-of-way but do not know the context in which this sign is used.
8. Double Turn Symbol	3.35	Difficulty in defining rules for each lane.
Warning Signs		
9. Large Arrow (sharp turn)	4.17	Confusion primarily with DETOUR arrow sign. Lack of awareness of yellow warning indication.
10. No Passing Zone Pennant	4.04	Drivers totally unfamiliar with unique shape. Unfamiliar with symbol meaning. Large "don't know" response - 43%.
11. Right/Left Turn	3.91	Severity not recognized. Right/Left TURN sign confused with right/left CURVE sign.

Table 8. Targeted Traffic Control Devices Posing Hazards if Misunderstood by Driving Public (Criticality Ranks > Overall Mean of 3.3) by Mean Ranks and Primary Misconception (continued)

12. School Crossing	3.74	Not recognized as a school traffic control. Confused with PEDESTRIAN CROSSING.
13. Chevron Alignment	3.48	General lack of comprehension of sign meaning. 50% - "don't know" response. Interpreted as a lane change command.
Construction Signs 14. Detour Arrow (no verbal message)	3.43	Confusion primarily with ONE-WAY TRAFFIC arrow. Lack of awareness of orange construction code.
Pavement Markings 15. Double Solid Yellow Center Marking	4.52	Unfamiliar with two-way characteristic of yellow markings. Unaware they may be crossed to turn left.
16. Broken Yellow Center Marking	3.96	Unaware that yellow means two-way traffic.
17. Two-Way Left Turn Lane Striping	3.57	Consider the lane for emergency stopping or a passing lane.
Signals 18. Red Beacon (flashing)	4.52	Flashing mode dilutes the command. Only a rolling stop or a check for clearance necessary according to 11%.
19. Pedestrian "Don't Walk" (flashing mode)	3.65	Pedestrians who have left the curb do not realize the flashing phase allows them time to cross. They consider themselves walking against the light and may stop at the center.

Table 9. Traffic Control Devices Posing Lesser Hazards by Mean Criticality Rank and Primary Misconception

Traffic Control Device	Mean Criticality Rank	Primary Form of Misunderstanding
1. Two-Way Left Turn Only Symbol Sign	3.26	Sign is easily misunderstood out of context. Misconceptions revolve around where to turn.
2. Advance Flagger Sign	3.22	Association with construction but not drawing attention to flagger as desired for possible redirection of traffic and safety of flagger.
3. Yellow Arrow/Circular Red Signal Indication	3.17	Drivers respond to circular red primarily, over the arrow.
4. Railroad Advance Warning Symbol Sign	3.09	Drivers almost unanimously expect sign to be at grade crossing rather than an advance warning.
5. Type III Barricade	3.09	Barricade is perceived as an obstruction that can not be passed. Significance of orange stripes completely overlooked.
6. Broken White Line	3.00	Unaware that white means one-way traffic.
7. Type VI Object Marker	3.00	When presented out of context, drivers do not identify this marker.
8. School Advance Symbol Sign	2.96	Not recognized as a school traffic control. Most often confused with pedestrian crossing or school crosswalk.
9. Stop Sign Ahead Symbol Sign	2.96	Drivers interpret this sign to mean "stop, then go straight".
10. Solid White Line	2.91	Drivers do not know that white means one-way and solid means not to cross line.
11. Green Arrow/Circular Red Signal Indication	2.70	Drivers respond to circular red primarily over the arrow. Unaware of protected turn. Large percent stop first, then turn.
12. Type III Object Marker	2.39	Unfamiliar with the function of this marker.
13. Climbing Lane Ahead Sign	1.70	Drivers associate the sign with an approach to a hill, but are unfamiliar with significance of climbing lane.

X. DRIVER UNDERSTANDING OF TRAFFIC CONTROL DEVICES: SUMMARY AND RECOMMENDATIONS

Increased technology associated with vehicles as well as traffic controls, and the increased complexity of the entire traffic system have led to a concern for the successful presentation of information needed by motorists. The purpose of this study was twofold:

(1) to determine, based on misinterpretation, confusion, or unfamiliarity, the information needs that exist for Texas motorists, and

(2) to assist the State Department of Highways and Public Transportation in providing educational and other strategies that will diminish the number of accidents caused by a lack of driver information.

LEVELS OF UNDERSTANDING

The use of four survey approaches to measure motorists' recognition and understanding of 63 traffic controls resulted in detailed findings regarding three levels of understanding. The first of these levels, understanding the meaning or inferred standard of a specific control device apart from environmental cues, was measured both in the laboratory and in the field. A small, representative sample of Texas drivers (94) identified traffic controls presented on slides in one phase of an in-depth interview. 372 drivers in selected driver licensing stations in Texas also identified traffic controls apart from environmental cues as they were presented in questionnaire booklets.

The second level of understanding is a perceptual differentiation of devices based on familiarity with a system of coding - color, shape,

symbol, or common usage coding. Familiarity with the shape and color system of coding was determined in the laboratory test.

A third level of understanding is one which takes into account the interaction effects of other communications, including environmental cues, the driving task, and familiarity with the traffic environment. This type of understanding was assessed in the real time, actual situation format of a film. Table 10 is a summary of correct responses for all of the traffic controls examined for each type of assessment.

Detection of traffic controls, the first dimension influencing their effectiveness, was discussed as affected by several factors - signal value (the basis on which traffic controls are detected or eliminated by the driver), and conspicuity (size, shape, color, brightness contrast, and surrounding complexity). As shown in Table 10, highest recall of physical characteristics was for the category of signs with the highest signal value - regulatory signs. The most familiar sign to the respondents, in terms of physical characteristics, was the SPEED LIMIT sign, which has been found to have a high signal value resulting from an awareness by motorists of enforcement efforts and the probability of punishment.

The physical characteristics (shape and color) of less frequently enforced signs with lower signal values (specifically, warning signs) were less often recalled by the respondents. Signs other than regulatory may also be less conspicuous in terms of color, brightness contrast, and their placement in more complex surroundings.

Motorists' level of understanding of signs, once they have been read, is dependent to some extent upon existing knowledge of a coding

Table 10. Percent Correct Interpretations of Traffic Control Devices by Survey Type (in percentages).

TRAFFIC CONTROL DEVICE	SURVEY TYPE - PERCENT CORRECT RESPONSE				
	SHAPE	COLOR	SLIDE	FILM	STATEWIDE QUESTIONNAIRE
PAVEMENT MARKINGS					
1. Broken Yellow Center Marking			86- two-way 85- passing	53	87- two-way 87- passing
2. Broken White Center Marking			47- one-way 92- passing	19	46- one-way 92- passing
3. Double Solid Yellow Center Marking			88- two-way 90- no passing	43	92- two-way 95- no passing
4. Broken and Solid Yellow Line Combinations			93- two-way 69- passing	70	93- two-way 65- passing
5. Solid White Line			66- one-way 49- crossing restricted	65	56- one-way 38- crossing restricted
6. Two-Way Left Turn Striping			56		59
7. Two-Way Left Turn Lane Pavement Markings				93	
8. Pedestrian Crosswalk Lines			75		
REGULATORY SIGNS					
9. Stop	56	87			78
10. Yield	40	25			83
11. Do Not Enter					45
12. Speed Limit	87	82		95	
13. Prohibitory Right Turn	53	43	64	68	89
14. One-Way Traffic			48		72
15. Keep Right	52	31	39		67
16. Do Not Pass	76	60			
17. Double Turn	81	58	70	81	53
18. Two-Way Left Turn Only	49	41	60	74	20
19. Climbing Lane Ahead			60		80
20. Yield To Traffic in Center Lane			13		
WARNING SIGNS					
21. Two-Way Traffic	14	43	79		98
22. Turn	18	53	82	80	62
23. Curve			75		95
24. Cross Road					92
25. Stop Sign Ahead			30		42
26. Signal Ahead					94
27. Merge			63	83	76
28. Pavement Width Transition			55	46	68
29. Divided Highway			65		
30. Deer Crossing	39	71	96		
31. Truck Crossing	29	50		95	
32. Fire Station	20	41	70	74	42
33. Pedestrian Crossing	21	74	81	86	86
34. School Advance			24	31	21

Table 10. Continued

TRAFFIC CONTROL DEVICE	SURVEY TYPE - PERCENT CORRECT RESPONSE				
	SHAPE	COLOR	SLIDE	FILM	STATEWIDE QUESTIONNAIRE
35. School Crossing	5	76	46	44	50
36. Slippery When Wet	38	71	54	74	81
37. Exit Speed Limit	81	30		24	
38. Pavement Ends			75		
39. Soft Shoulder			85		
40. Large Arrow					18
41. No Passing Zone	1	42		81	27
42. Railroad Advance	58	40	2	33	17
43. Chevron Alignment			37	62	23
CONSTRUCTION SIGNS					
44. Advance Flagger	23	24	53	64	62
45. Low Shoulder			6		63
46. Advance Road Construction	24	42		100	
47. Detour Arrow					53
BARRIERS and DELINEATORS					
48. *Type III Object Marker			20	41	44
49. *Type VI Object Marker					20
50. *Type III Barricade			2		1
SERVICE INFORMATION, and GUIDE SIGNS					
51. Next Exit Supplmental Sign	77	60			
52. Hiking Trail			21		
53. Hospital	70	35	69	90	86
54. Travel Trail Marker			12		
55. Recreational Interest Area	0	12			
SIGNALS					
56. Yellow Beacon/Flashing Mode				98	54
57. Red Beacon/Flashing Mode					87
58. Red "X" Lane Use Control				50	
59. Green "↓" Lane Use Control				55	
60. Circular Green/Green Arrow			98		
61. Circular Red/Green Arrow				55	59
62. Circular Red/Yellow Arrow			17		18
63. Dont Walk/Flashing mode			10		65

*Discussion not incuded in Chapter VI. Details of analysis are available.

system. This knowledge was found to be lacking, in general, in the majority of the respondents. Particularly, the use of orange for construction signing was unfamiliar to them.

Regulatory signs as a group were better understood than warning, construction, or other signs. It was found, however, that a great deal of dependence upon words exists for drivers. For example, STOP, YIELD, DO NOT ENTER, and the ONE-WAY TRAFFIC ARROW, signs, all posed problems in interpretation for the drivers surveyed, when their word messages were omitted. The DO NOT ENTER sign was misinterpreted by 55 percent of the respondents by symbol alone.

In other studies (Hulbert, et al.), it has been found that, in general, symbol signs are understood better than signals or pavement markings. To a certain extent, this study supports the premise that symbols are less problematic than several other communications. Some symbol signs are very well understood. The TWO-WAY TRAFFIC sign, the DEER CROSSING sign, and the CURVE signs were understood by 95 percent or more of the respondents. However, other symbol signs cause confusion among motorists. Newer signs such as the STOP SIGN AHEAD symbol sign and the PAVEMENT WIDTH TRANSITION signs were unfamiliar to a significant segment of the drivers questioned. The evidence suggests that supplemental messages or educational plaques are necessary at present for many of the symbol signs (e.g., the SLIPPERY WHEN WET sign, prohibited turn signs, MERGE, and construction symbol signs). It was discovered that signs such as these have various meanings for drivers that are incorrect.

These problems occur within the second and third dimensions of influential factors on the effectiveness of traffic control devices - reading and understanding (see Figure 1, Chapter I). Symbol characteristics are first read. The successful reading of the sign is affected primarily by two features: legibility and information processing capabilities. Limitations in each of these areas are responsible for misunderstood symbol signs in many cases. The symbol characteristics themselves, in some cases, are too vague. For example, the PAVEMENT WIDTH TRANSITION symbol, the STOP SIGN AHEAD symbol, and the ADVANCE FLAGGER symbol, seemed to have very ambiguous messages for many respondents. Additionally, advance warning signs present a difficult concept for the driver to assimilate, i.e., an advance versus an on-site traffic control device.

Differences among individuals produce a range of information processing abilities that determine how well signs can be read and understood. In regard to symbol signs, ethnic minorities, older drivers, and the lower educated were more likely to misinterpret the intended meaning of the symbols.

A dependence upon other cues was evidenced for the interpretation of pavement markings. Comprehension of the coding system when presented with no environmental cues was low for several of the markings. Respondents showed little understanding of the difference between yellow and white in defining direction of travel.

Evidence obtained from in-depth interviews where pavement markings were presented in context point to the low signal value and low conspicuity of the lines used. Their value to motorists who are not

completely familiar with their meaning was in marking lanes. One well known feature, however, was the prohibition against passing on double solid yellow lines. Perhaps detection of this meaning is associated with perceived risk.

Understanding of these traffic controls, i.e., pavement markings, was found to be very much a factor of education, and less attributable to level or length of exposure. The findings showed that those drivers with the highest level of understanding were those who had taken a driver education course. This characteristic was the most important to overall understanding of the road marking code system.

The third type of traffic control assessed in this study was signals. Four features of traffic control signals that affect driver understanding are: (1) knowledge of color indications; (2) recognition of other environmental cues, including other traffic controls; (3) location and uniformity of location of signals; and (4) design aspects of signals. Of these four features design aspects were found to be most important regarding confusing behavioral responses. To be specific, certain combinations of signal indications on the same signal face, such as arrow and circular indications of contradictory colors, resulted in indecision on the part of the respondents as to which indication to obey or if a combination of maneuvers was indicated. Additionally, arrows and "X"'s on LANE-USE CONTROL signals were not sufficient information for many drivers (and may lack conspicuity as well).

The meaning of flashing signal indications represents a problem for many motorists. In the case of beacons, the problem is that they do not know what to expect from intersecting traffic. Flashing red beacons

were found to have less signal value for drivers; however, flashing DONT WALK signal indications had more target value for pedestrians.

In providing an overview with respect to level of understanding of the 63 traffic control devices examined in this study, the following general statements can be made:

- There is a lack of knowledge of the meaning of shapes and colors of signs.
- A significant number of drivers are unfamiliar with basic principles of the road marking system.
- Regulatory signs are the most effectively detected, read, and understood, relative to other signs. They have the highest signal value. However, the importance of wording on verbal messages and conspicuity of signs should be recognized.
- Less than 80 percent of the drivers were certain of the meaning of one-half the warning symbol signs analyzed.
- Many drivers are confused by traffic control complexity exhibited in signal displays - arrow/circular combinations, flashing indications, and lane-use control signals.

RECOMMENDATIONS

The survey results presented herein document the existence among Texas drivers of confusion, misunderstanding, and unfamiliarity with certain traffic control devices. Consequences of driver conceptual limitations vary according to traffic control device. As pointed out earlier, if five percent of the driving public incorrectly identify the ONE-WAY TRAFFIC regulatory sign, the accident potential is much greater than if 95 percent of the state's drivers are unable to identify the Texas Travel Trail marker. Although measures could be suggested for improving the effectiveness of all traffic control devices, a

Table 11
Most Critical Traffic Control Devices and Recommended Countermeasures

Traffic Control Devices	Recommendations and Countermeasures
Regulatory Signs	
* 1. Do Not Enter Symbol Sign (no verbal message)	Do not delete verbal message. Implement educational campaign aimed at segment without driver education training.
* 2. Stop Sign (no verbal message)	Confirmation of standards as applied.
* 3. YIELD (no verbal message)	Confirmation of standards as applied.
* 4. One-Way Traffic (no verbal message)	Confirmation of standards as applied. Inform drivers of color code for regulatory versus warning versus construction signs.
* 5. Prohibited Right Turn	Accompany sign with educational plaque. Implement educational campaign for young, old, and female drivers.
6. Keep Right	Accompany sign with educational plaque.
7. Yield to Traffic in Center Lane	Discontinue use.
8. Double Turn Symbol	Supplement with advance verbal message defining lane use.
Warning Signs	
* 9. Large Arrow (sharp turn)	Inform drivers of color code for regulatory versus warning versus construction signs.
*10. No Passing Zone Pennant (no verbal message)	Implement educational campaign to increase driver awareness of this sign and its shape and color meaning.
*11. Right/Left Turn	Accompany all TURN signs with advisory speed plates.
12. School Crossing	Educate public on school area verus general warning signs. Accompany sign with educational plaque.
13. Chevron Alignment	Establish warrants for use. More research needed on double-face usage.
Construction Signs	
14. Detour Arrow (no verbal message)	Inform drivers of color code for regulatory versus warning versus construction signs.

Table 11
Most Critical Traffic Control Devices and Recommended Countermeasures (continued)

Traffic Control Devices	Recommendations and Countermeasures
Pavement Markings	
*15. Double Solid Yellow Center Marking	Educate public on white versus yellow pavement markings for directional information and on ability to cross for left turns.
*16. Broken Yellow Center Marking	Educate public on white versus yellow pavement markings for directional information.
17. Dual Turn Lane Striping	Use Two-way Left Turn arrow pavement markings.
Signals	
*18. Intersection Control Beacon (Red)	Convey to public the requirement to STOP at all red signals.
19. Pedestrian (Don't Walk Flashing)	Allow ample time to cross during clearance phase. Greater understanding and consistency with other signals would result from three phases - a green walk phase, a yellow intermediate phase, and a red don't walk phase.

*Understood by less than 90 percent of respondents.

Table 12
Misunderstood, Critical Traffic Control Devices and Recommended Countermeasures

Traffic Control Devices	Recommended Countermeasures
1. Two-Way Left Turn Only	Accompany sign with arrow pavement markings.
2. Flagman Ahead Symbol	This sign should be accompanied by an educational plaque.
3. Yellow Arrow/Circular Red Signal Indication	Educate public on appropriate response to arrow signal indications. Do not display arrow and circular indications of different colors on the same signal face without an additional information plaque indicating left turn arrow right-of-way.
4. Railroad Advance	Supplement with pavement markings. Educate the public on advance versus on-site treatments.
5. Type III Barricade	Directional coding must be supplemented by directional arrows at all times.
6. Broken White Line	Educate public on white versus yellow pavement markings for directional information.
7. Type VI Object Marker	Drivers need instruction on the meaning of object markers
8. School Advance	Educate public on school versus general warning signs. Inform drivers of distinction between school advance and school crosswalk signs.
9. Stop Sign Ahead Symbol	Accompany this sign with educational plaque.
10. Solid White Line	Educate public on white versus yellow pavement markings for directional meaning; and solid versus broken stripes for passing restrictions.
11. Green Arrow/Circular Red Signal Indication	Educate public on appropriate response to arrow signal indications. Do not display arrow and circular indications of different colors on the same signal face without an additional information plaque indicating left turn arrow right-of-way.
12. Type III Object Marker	Drivers need instruction on the meaning of object markers
13. Climbing Lane Ahead	Delete sign and use SLOWER TRAFFIC KEEP RIGHT to relay intended message.

criticality ranking technique was deployed to recommend target traffic controls for countermeasure approaches.

The traffic controls considered most critical by a panel of knowledgeable traffic professionals, in terms of hazards posed, that were also commonly misunderstood are presented in Tables 11 and 12. Table 11 is a list of traffic controls identified as most critical that were understood by less than 90 percent of respondents in the starred cases and by less than 80 percent for the remainder of the cases listed. Table 12 are controls that were understood by less than 50 percent of the drivers surveyed. The recommended countermeasures listed are based on the primary form of misunderstanding or confusion associated with each sign.

Basically, four types of recommendations and countermeasures can be made to improve the effectiveness of misunderstood traffic controls.

I. CONFIRMATION OF EXISTING STANDARDS AND SPECIFIED APPLICATIONS

Some signing and traffic control practices are effective enough as they are used currently, but the study shows that changes would have detrimental effects. For instance, the STOP sign, YIELD sign, DO NOT ENTER sign, DETOUR and ONE-WAY TRAFFIC arrow signs should continue to have a written message on them. The evidence shows that a significant portion of the driving population would either misinterpret or disregard these signs as symbols alone.

II. NECESSITY FOR SUPPLEMENTAL INFORMAITON ASSOCIATED WITH DESIGNATED TRAFFIC CONTROL DEVICES.

Educational plaques are currently necessary for understanding symbol signs such as SCHOOL CROSSING, NO RIGHT TURN, SLIPPERY WHEN WET, and the ADVANCE FLAGGER sign. Motorists also need information or on-site instruction for the meaning of LANE-USE CONTROL signal indications, the safe speed at which to negotiate severe turns, and signs that define directions of travel in addition to pavement markings.

III. REVISIONS OF CURRENT APPLICATIONS RELATIVE TO SPECIFIC CONTROL DEVICES

Upon re-evaluation, it is recommended that some aspects of the communication system of traffic controls need to be changed. This includes development of alternative controls to replace ineffective ones. In some cases, deletion of one control in favor of another control in existence that is more effective and lessens driver overload is warranted. For example, the CLIMBING LANE AHEAD should be deleted and the SLOWER TRAFFIC KEEP RIGHT sign used singularly to convey the intended message. Finally, the display of contradictory colors of arrow/circular indications on the same traffic signal face should be discouraged, or accompanied by an educational plaque if used.

IV. RECOMMENDATIONS FOR PUBLIC INFORMATION AND EDUCATION EFFORTS.

One of the most effective ways to enhance the roadway communication system is to educate those to whom the communciation is directed.

Driver education and driver improvement programs are positive predictors of knowledge of traffic controls. Attention should be given in these programs to the pavement marking code, the shape and color code, the meaning of symbol signs, and correct responses to the more complex traffic signal indications.

These efforts should also be directed at the driving public at large. Information can be transmitted in driver license stations. Public service announcements and educational campaigns are other strategies that can be used to educate the public at large. These approaches may also be quite effective in reaching "targeted" groups who have specific information needs.

Among the many controls warranting educational countermeasures, the following are particularly critical: DO NOT ENTER symbol sign; color code distinctions among ONE-WAY TRAFFIC, LARGE ARROW (sharp turn), and DETOUR arrow signs; PROHIBITED RIGHT TURN: crossing (on-site) versus advance signs, such as SCHOOL CROSSING and SCHOOL ADVANCE; and the directional aspects of pavement markings.

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