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16. Abstract
This report outlines the objectives of the research project conducted by the Texas Transportation Institute entitled, "Evaluating Urban Freeway Guide Signing." The research was sponsored by the Texas Department of Highways and Public Transportation, Federal Highway Administration. An extensive state-of-the-art is included in this report.

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OBJECTIVES AND STATE-OF-THE-ART
OF
URBAN FREEWAY GUIDE SIGNING SYSTEMS

by

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Research Report 220-1

Research Study 2-18-77-220

Sponsored by the

State Department of Highways and Public Transportation

in cooperation with the

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Federal Highway Administration

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SUMMARY

A literature review indicates that recently many studies have been made in the areas of highway signing and its methods of evaluation. Both laboratory and field studies have been employed in evaluating freeway guide signing. This research study, Evaluating Urban Freeway Guide Signing, has involved both laboratory testing and field testing of several critical areas in freeway guide signing to determine where modification for the state of Texas should be considered. The results of this research effort will be documented in a series of reports. These reports are as follows:

220-1 - Objectives and State of the Art of Urban Freeway Guide Signing Systems

220-2 - Field Studies and Inventory of Freeway Guide Signs

220-3 - Laboratory Studies of Urban Freeway Guide Signing

220-4 - Level of Service Criteria and User's Manual for Urban Freeway Guide Signing Systems

220-5 - Executive Summary and Significant Findings (Final Report)

These reports present the test results in a manner which can be readily used by both traffic and design engineers for both modification of existing freeway guide signs and new signing systems.

IMPLEMENTATION STATEMENT

The overall objective of this study is to determine the nature and extent of the urban freeway guide signing problem in the state of Texas. After isolating the major problem areas, detailed research in the form of laboratory and field studies is currently being performed on alternative solutions to the problems. The results of these laboratory and field studies will be used, in conjunction with "Level of Service" criteria established throughout the course of this project, to develop a user's manual to be used by the State Department of Highways and Public Transportation in a major freeway guide signing improvement study.

This report is the first of a series to be developed from the results of this project. As these subsequent reports become available it is highly recommended that the results be implemented.

DISCLAIMER

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CHAPTER 1

INTRODUCTION

PROBLEM STATEMENT

Methods to eliminate motorist confusion at high-speed interchanges are needed on high-volume urban freeways. The signing of these facilities poses particular problems due to close interchange spacing, multiplicity of exits, and the large number of intersecting arterials. At present, there is much confusion at numerous interchanges throughout the states with regard to route guidance signing that additional research is needed to establish criteria for evaluating signing at these locations (1).

Our present state-of-the-art in freeway signing is unsatisfactory from a number of standpoints, particularly in regard to route guidance. First, external visual signals are network-oriented and not driver-oriented. Road signs giving guidance information concisely indicate where the road goes, not where the driver is to go. The driver must have preplanned his route and may require some foreknowledge of the roadside signing in order to negotiate the maze of roadways which comprise his trip. Second, only a small portion of the total roadside signing is pertinent to a given driver's trip, resulting in a high degree of nonuseful information. Because a driver cannot indiscriminately reject all road signing without the risk of rejecting that which is pertinent, he is forced to continually keep watch over the signing along the route driven. Third, external visual signals are impaired whenever visibility is impaired, as in night driving, bad weather, and the obstruction due to the heavy traffic or large vehicles (2).

BACKGROUND

Literature regarding urban freeway guide signing is incomplete and somewhat conflicting (3). Several researchers have pointed to driver hazards resulting from confusion and indecision associated with guide signing (4, 5). Others have focused on accident experience correlating with route guidance signing (6). The need for route signing/geometric design continuity has been emphasized (7, 8).

Operationally, guide signing has proven effective in reducing some problems at freeway interchanges. The high incidence of erratic maneuvers at these locations and their reduction with effective signing indicates that drivers have a high degree of path and/or directional uncertainty (9). Evidence also purports the real or potential ambiguity of selected verbal messages used in present guide signing practice (10). These factors coupled with driving task decisions which must be made quickly and within short distances at high speeds induce hazardous situations.

In the past, guide signing studies have been concerned with the comparison of various alternate configurations of signing components without attempting to validate measures of guide signing effectiveness, particularly as these relate to motorist response (11, 12). The result is that many operational techniques have been developed and used, both in the laboratory (13, 14, 15) and in the field (1, 9). However, the relationships between the soundness of the recorded variables is unknown; and, little attempt has been made to relate the two approaches - Laboratory and Field. A recent review of methodology in traffic sign research (16) points out difficulties specific to each approach. These difficulties will be discussed in a later section.

SCOPE

Deficiencies obviously exist at both point and system navigational levels which pose a significant problem to practicing traffic engineers. An effective assessment technique is vitally needed. This state-of-the-art will lend direction to the subsequent goal of developing an evaluation criteria and practical methodology for improving the quality of urban freeway guide signing. A systematic review and discussion of the literature will be presented in Chapter 3 for following major topic areas:

- Current standards and practice in urban guide signing
- Navigational and guidance information needs
- Driver expectancy and preferences in guide signing
- Measures of effectiveness and evaluation techniques

CHAPTER 2

RESEARCH APPROACH

OBJECTIVES

The research objectives during the first three years of this study, which began on September 1, 1976, were as follows:

1. To develop a method of identifying principal urban freeway navigational information needs considering the through freeway section with right and left-hand exit ramps and direct connecting roadways.
2. To develop a systematic framework for identifying acceptable and deficient navigational signing along urban freeways taking into account the existing pavement markings and geometric features.
3. To develop and test a practical field evaluation technique for identifying acceptable and deficient navigational signing and its relationship to pavement markings and geometrics along urban freeways.
4. To develop a data base of several Texas cities that can be used for developing remedial treatments and new design criteria for freeway guide signing systems. This data base includes information on existing pavement markings and geometrics.
5. Evaluate before and after effects of current urban freeway guide signing improvement projects along I-10 in Houston and I-30 in Dallas.

6. To develop a set of urban freeway guide signing improvement strategies and evaluate these strategies using visual laboratory scenario techniques.
7. To develop an inventory of urban freeway guide signing and geometrics in Atlanta, Kansas City, Denver, Los Angeles, New Orleans, and Chicago. The inventory will be similar to that developed of Houston and Dallas.
8. To determine the advantages and disadvantages of removing U.S. route markers from Interstate sign panels.

The objectives for the fourth year are as follows. A subsequent report covering the activities for the fourth year will be forthcoming at the appropriate time.

9. To develop an alternative numbering system for the U.S. and/or state routes which exit the Interstate to go through a city or cities and then return to the Interstate.
10. To determine the best approach and method of eliminating the U.S. and/or state route markers. A strategy will be developed for implementing the removal of the U.S. and/or state route markers.
11. To determine the informational needs and requirements of closely spaced left-hand exits.
12. To develop signing systems which fulfill those informational needs of the motorists and the testing of these signing systems through laboratory studies and field testing.
13. To develop guidelines for evaluating and improving urban freeway guide signing in Texas, including guidelines for

modifying pavement markings and geometrics to permit improved guide signing.

14. To develop "Level of Service" criteria and methodology for characterizing and evaluating urban freeway guide signing which includes the effects of all levels of the driving task. Where applicable, show how Level of Service can be improved with pavement markings and geometric modifications.
15. To evaluate the guide signing Level of Service on at least two (2) major freeways in Houston, Dallas, Fort Worth and San Antonio.
16. To develop a Level of Service User's Manual to be evaluated through field testing and by the Districts.

RESEARCH METHODOLOGY

Due to the nature and complexity of the problem this research project addresses several research techniques have been used. The techniques used in this research project are:

1. 35 mm slide inventory
2. Audio-video film inventory
3. Laboratory studies
4. Field studies

To define the general nature of the problem and isolate specific problem areas, a 35 mm slide inventory of route guidance signs on freeways in Dallas and Houston was made. Approximately 500 slides were taken to form the data base for this project. During the third year of this project a similar inventory was conducted in Atlanta, Georgia; New Orleans, Louisiana;

Chicago, Illinois; Kansas City, Missouri; Denver, Colorado; and Los Angeles, California. An audio-video film inventory was also conducted to supplement the 35 mm slide inventory.

After an extensive review of both the 35 mm slide inventory and the audio-video film inventory, several areas of route guidance sign messages were isolated for further investigation. The following areas were selected for study using a laboratory-scenario technique:

1. Designation of Routes to the Downtown Area
2. Formatting and Method of Presenting Route Transfer Information
3. Reading Times of Freeway Guide Signs
4. Target Value of Different Types of Route Guidance Shields
5. Concurrent Signing - Motorist Understanding
6. Concurrent Signing - Route Number Reduction
7. Control City Information
8. Suburb Signing
9. Right-hand Interchanges Exiting Systems
10. Left-hand Interchanges Exiting Systems

The research methodology employed in each of these areas and the corresponding results of the laboratory studies are documented in Report 220-3.

Before and After operational studies were conducted along I-30 in Dallas and I-10 in Houston. Signing changes along both freeways took place during the course of this research study. It was determined that a Before and After study of changes in traffic flow distribution created by changes to the route guidance signing should be performed. The results of these two studies are documented in Report 220-2.

REPORTS

A series of reports, of which this is the first, will be developed during the course of the project. The sequence of these reports will be as follows:

220-1 - Objectives and State of the Art of Urban Freeway Guide Signing Systems

220-2 - Field Studies and Inventory of Freeway Guide Signs

220-3 - Laboratory Studies of Urban Freeway Guide Signing

220-4 - Level of Service Criteria and User's Manual for Urban Freeway Guide Signing Systems

220-5 - Executive Summary and Significant Findings (Final Report)

These reports present the test results in a manner which can be readily used by both traffic and design engineers for both modification of existing freeway guide signs and new signing systems.

CHAPTER 3

STATE-OF-THE-ART

CURRENT STANDARDS AND PRACTICE

GENERAL

Current Standards for urban freeway guide signing are instituted primarily from the National Manual on Uniform Traffic Control Devices (17) for streets and highways which is adopted and supported by the Texas Manual on Uniform Traffic Control Devices (18). Specific requirements for the Interstate Highway System (19) have been incorporated with amendments into the MUTCD to provide one document of practice applicable to all roadway facilities.

NATIONAL

Several statements of policy and principles relating to urban freeway guide signing are presented in the MUTCD. These are as follows:

Section 2D-2: Guide signs are essential to guide vehicle operations along streets and highways, to inform them of intersection routes, to direct them to cities, towns, villages, or other important destinations, to identify nearby rivers and streams, parks, forests, and historical sites, and generally to give such information as will help them along their way in the most simple, direct manner possible.

Section 2E-15: On all Exit Direction signs, both overhead and ground-mounted arrows shall be upward slanting and be located on the appropriate side of the sign.

Downward pointing arrows are lane assignment arrows and shall be used only for overhead guide signs to prescribe the use of specific lanes for traffic bound for a destination or route that can be reached only by being in the lane(s) so designated. These arrows may be tilted where it is desired to emphasize the separation of roadways.

Section 2F-2: The development of a signing system for freeways must be approached on the premise that the signing is primarily for the benefit and direction of drivers who are not familiar with the route or area. The signing must furnish drivers with clear instructions for orderly progress to their destinations.

Section 2F-3: Drivers should be confronted with consistent signing on the approaches to interchanges, as they drive from one State to another, when driving through rural or urban areas, Geographical, geometric, and operating factors regularly create significant differences between urban and rural freeway conditions, and the signing must take these into account.

Section 2F-7: The course of the freeway route and the major destination or "control cities" along it must always be clearly identified. Destination legends should provide the drivers the best orientation possible. Continuity in successive sign messages and consistency with available map information are essential.

Section 2F-9: A route diverging from a freeway should not be posted with any of the same destination names as are shown at that point for the freeway route. At any decision point, a given destination shall be indicated over only one route.

Section 2F-19: Interchange exit numbers shall be displayed with each advance guide sign, the exit direction sign, and the gore sign. They may be used with supplemental guide signs and service signs. The exit number preferably is to be displayed on a separate panel at the top of the major sign.

Where numbered freeway routes overlap, continuity of interchange numbering shall be established for only one of the routes. Either route may be selected, but the one chosen should also have continuity in mile-posting.

Section 2F-20: As in the case of expressways with grade separations, the major signs at freeway interchanges and on their approaches are advance guide signs and exit direction signs. It is essential that the same destination messages be displayed on these signs. New destination information should not be introduced into the major sign sequence for one interchange, nor should information be dropped.

Section 2F-22: Motorists need signs to help identify the geometric layout of interchanges, as well as to obtain route, direction and destination information for specific exit ramps. Signing layouts, therefore, must be consistent for each type of interchange. For the sake of uniform application the significant features of the signing plan for each of the more frequent kinds of interchanges should be followed as closely as possible. Where unusual geometric features exist, variations in signing layout are permissable, but should be held to a minimum.

Section 2F-23: Interchanges between freeways are major decision points where the effect of taking a wrong ramp cannot be easily corrected. Reversing direction on the crossing highway or reentering to continue on the intended course is usually not possible. The sign messages should contain only the route shield, cardinal direction, and the name of the next control city on that route.

Section 2F-24: Diagrammatic Signs are guide signs that show a graphic view of the exit arrangement in relationship to the Main Highway. Use of such guide signs have been shown to be superior to conventional guide signs for some interchanges. Diagrammatic signs should be used at the advance guide sign locations for left exits and for some Interchanges between Freeways and Interchange lane drops. They should be used for splits having off-route movements to the left, optional lane splits, exits with route discontinuity and left exit lane drops. Diagrammatics may be used at two-lane exits with an optional lane.

Section 2F-26: The advance guide sign, for cloverleaf interchanges, should include two place names, one corresponding to each exit ramp, with the names of the place served by the first exit on the upper line. An overhead sign shall be placed at the theoretical gore point of the first exit ramp, with an upward-slanting arrow on the sign for that exit and the message ($\frac{1}{4}$) Mile on the sign for the second exit.

Section 2F-29: The signing layout for all interchanges having only one exit ramp in the direction of travel should be similar, regardless of the interchange type. The singular message EXIT shall be used on advance guide and exit direction signs. Exit numbers shall not include the cardinal initials corresponding to the direction of the cross route.

Section 2F-31: When a series of interchanges is closely spaced, the advance guide sign for the next interchange should be mounted on an overhead structure located downstream from the gore or the preceding interchange. Information sequence series signs should be used. When used, they should identify and show street names and distance for the next three exits.

Section 2F-40: As in the case of expressways, route markers on freeways will ordinarily be incorporated as shields or other distinctive shapes into large directional guide signs. The use of independent markers on freeways will be limited primarily to route confirmation assemblies.

Section 2F-41: Where the crossroad is a numbered route or leads to other destinations, the advance guide and exit direction signs shall retain the white on green color combination. All gore signs shall remain with a white legend on a green background. The background color on interchange exit number panels shall match the color of the guide sign proper.

STATE

The Texas MUTCD is essentially a reiteration of the National guidelines with more emphasis on the standards used in the state of Texas.

The three principal types of urban freeway guide signing are defined as follows:

(1) The Advance Guide Sign notifies the driver well in advance of the intersection highway (or highways) and the principal destinations served by the next interchange as well as the distance to that interchange.

(2) The Exit Direction Sign repeats the highway and destination information displayed on the Advance Guide sign and provides drivers with more specific information concerning the action they should take to reach the exit. For any given exit, no more than one Exit Direction sign, located on the immediate approach to the interchange, is used.

(3) The Gore Sign is erected at the point of departure, where drivers leave the through traffic lanes. Depending upon the defined conditions, the Gore sign carries the word "Exit," or repeats route and destination information previously displayed to the driver on the Advance Guide sign(s) and the Exit Direction sign.

For the purposes of advance signing, freeway interchanges shall be classified as major, intermediate, and minor. The following are recommended signing practice for all classes of freeway interchanges:

(1) It is intended that the full complement of signs will be installed at all major interchanges. In urban districts, however, and at times in high population density rural districts, the interchanges of this type may be so closely spaced as to make two Advance Guide sign installations not feasible, and under these conditions, one Advance Guide sign will be permitted. Interchange Sequence signs, referred to later, are useful in orienting drivers when adequate space for two Advance Guide signs is not available.

(2) At intermediate interchanges, there shall be one or two Advance Guide signs depending upon specific conditions and the relative need for advance information.

(3) At minor interchanges, there shall be at least one Advance Guide sign.

Standards are presented which detail the purpose and application criteria for the general sequence of freeway guide signs. These are given by the following eleven signs:

The OVERHEAD GORE sign indicated the place of departure from the main lanes of a Freeway. However, the Overhead Gore sign repeats the highway and/or destination information shown on the Advance Guide sign(s) for that exit.

The EXIT DIRECTION sign is used to advise drivers of the exit maneuver from a Freeway. The sign repeats the route and/or destination information for the next exit that was shown on the Advance Guide signs and thereby assures the driver of the destinations served and indicates whether he leaves on the right or left for that destination. When interchanges are numbered, the appropriate EXIT NUMBER panel shall be attached to the top of the Exit Direction sign.

The ADVANCE GUIDE sign is used on Freeways to give notice well in advance of the interchanging highway, road or street of the principal destinations served by the next interchange and the distance to the interchange. When interchanges are numbered, the appropriate EXIT NUMBER panel shall be attached to the top of each Advance Guide sign. The exit number shall not be displayed within the border of the Advance Guide sign.

The OVERHEAD CONFIRMATION sign is used in an overhead sign installation over the main lanes of Freeways to confirm to motorists the highway route and the next principal destination served by that route. This sign shall usually be mounted on the same overhead structure that carries the OVERHEAD GORE sign at an exit ramp, and it will usually be positioned over the left hand lane or lanes.

The DIAGRAMMATIC sign is representative of the various diagrammatic signing layouts that may be used. Symbolic and diagrammatic designs are easily recognized and instantly provide the motorist with necessary guidance information. The interchange diagrams and information conveyed should be as straight forward and simple as possible.

The NEXT EXIT ( ) MILES sign is for use on Freeways where the distance to the next interchange is such that a driver failing to make a desired turn would be required to travel a number of miles out of his way. It may be desirable to use this sign as a supplementary panel mounted below the Advance Guide sign nearest the interchange where the distance to the next exit beyond the one for which the Advance Guide sign is posted exceeds 5 miles.

The SUPPLEMENTAL GUIDE sing may be used on Freeways when it is necessary or desirable to provide more information regarding destinations accessible from a multi-exit interchange than can be shown on the standard Advance Guide signs which are limited to two destinations.

The NEXT ( ) EXITS sign may be used on Freeways which pass through historical or recreational regions, or urban districts, which are served by a succession of several interchanges. Such regions or districts may be indicated by this sign erected several miles, if possible, or at least 800 feet in advance of the first Advance Guide sign for the first interchange.

The INTERCHANGE SEQUENCE sign may be used on Freeways where exits are very closely spaced for some distance, particularly through large urban districts, to show a maximum of three destinations, or interchange highway names, or route number, and mileages or fractions thereof to the appropriate interchange serving such destinations or highways.

The OVERHEAD THRU TRAFFIC sign is used in an overhead sign installation over the main lanes of freeways to confirm to the motorist those lanes that are primarily for through traffic movement.

The MILEAGE sign may be used on Freeways to show the distance to the next city or interchanging highway along the route, the name of a community of general interest, or a major traffic generator served by the highway, as well as the name of a control city or terminal destination of the highway. A general observation is that this is not being done except in the Houston urban area.

The DESTINATION sign may be used on ramps or frontage roads of Freeways to show up to 4 destinations that can be reached by way of the numbered of unnumbered interchanging highway, road, or street. The destinations shown shall be those shown in the Advance Guide sign and the Exit Direction sign used in advance of the interchange, as well as those shown on the Supplemental Guide sign, if one is used.

NAVIGATIONAL AND GUIDANCE INFORMATION NEEDS

Driving Task

Traffic engineers are under increasing pressure to make the highway system more responsive to the information needs of the motorist. The information that will enable the motorist to drive safely, effectively, conveniently, and comfortably must be transmitted to him (32).

Insight into the nature of the driving task is desirable to determine the informational needs of the motorist to allow performance of the driving task. The driving task is the driver's actions based on his view of the road, his desired path, error estimation of desired versus actual path, and perception of "error correction" motions. The driver samples information from many sources integrating it continuously to maintain a current overall appreciation of the changing scene. He infers ahead and performs continuous predictions of the future based on this perception of position and rate. Driving requires a succession of decisions by the driver. The basic driving task has a structure of three elements - control, guidance and navigation. The driver places these three elements into a hierarchical structure starting with the control element and progressing to the navigational element.

The control (positional) subtask deals with the driver's interactions with his vehicle. The interactions are concerned with the vehicular longitudinal and lateral control. The guidance (situational) subtask is the driver's ability to maintain a safe path on the highway (33). A driver has a desired path he wished to follow. Information for this subtask performance comes from the highway-alignment, configuration, striping, regulatory and warning signs, hazards, shoulders, and other traffic location and behavior. Thus two guidance subtasks related to the selection and maintenance of a safe path and speed (12).

The navigation subtask is the driver's planning and execution of his trip. Maps, verbals, directions, signing, visual queues, and landmarks are typical informational sources. These information sources must be understood and used effectively to accomplish the trip. This is related to trip planning, route following, and direction finding (32).

The total driving task is a series of interrelated tasks performed independently and conditionally. The driver must perceive and interpret the informational field sources transmitted to him through the various sensory channels. He is required to sift through this information, determine its relative importance, make proper interpretations, decide on a course of action and take that action in a limited period of time (20).

The hierarchy of control, guidance, and navigation subtasks makes up the tasks performance complexity. At the control level, performance is relatively simple, and is overlearned so as to be performed by rote. At the guidance and navigational levels performance is increasingly complex and drivers need more time to respond to informational input (33).

Information Needs

Driving requires a succession of decisions. The rate at which decisions can be made becomes important. Information can be regarded as the resolution of uncertainty. The driver uses information imperfectly. The driver filters and classifies many informational inputs for purposes of response selection. Information relevance and redundancy are probably the most important content factors. Irrelevant or excess information acts to increase overall search time. It generally increases reaction time, and produces response competition. Complex tasks, such as driving, are detrimentally affected by irrelevant information. Search time generally increases linearly with the amount of irrelevant information and there is no learning effect on the part of the subject. The informational needs and requirements of motorists have been shown to have a significant impact on their driving behavior and information processing capabilities. Several studies (73, 74, 75) have been conducted for specific situations in which improvements in information content or presentation methods have significantly affected driver behavior.

The driver's requirement is to perceive accurately all the actual and potential obstacles at any given time and to know the vehicle's capability given any combinations of road, speed, and conditions. The driver is vulnerable to several errors. These are perceptual vulnerability (failure to observe), skill vulnerability (neglect of driving dkill), change vulnerability (vehicle failure, environmental failure), and judgement vulnerability (incorrect decision).

The driver is the main controlling element in the highway system, his ability to perform within the system determines the system's ability to perform its intended function. The road complex must provide for the operator a comprehensive display of information both in the formal sense of signs, markings, and delineation, and in the informal sense of clear visibility in all relevant directions.

The highway generates a need for information. One of the most important parts of the driving task is the maintenance of a steady-state relationship of the vehicle with the fixed highway elements and the implementation of conscious and deliberate changes in the relationship. The highway affects the transmission and reception of all information necessary for the driving task. Visual communications have been and are presently the primary means of transmitting information to the driver.

The driver must evaluate all information sources to determine which he deems important. The relative priority of handling information is accomplished through primacy. The primacy concept is based on the driver's basic criteria in the driving task being his (and vehicle) safety.

The navigational task expectancies are predicated on the driver's preconception that the highway signing will direct him to his destination or principal routes. The driver has no way of predicting what destination will appear on signs. He has reasonable expectations that his destination will appear on highway guide signs. The unprepared trip maker can be expected to experience uncertainty and/or confusion at some points along his path (8).

The driver brings to the driving task his a priori knowledge and skills (12). A priori knowledge relates to each level of the driving task, and different aspects of it affects the driver's ability to accomplish the subtasks (20). This general a priori knowledge is supplemented by the knowledge gained on the specific trip. The driver is assumed to have basic operating skills and knowledge of rules and regulations, and general analytical ability to accomplish the tasks associated with the driving environment of estimation, interpretation, and comprehension.

The information overload potential along certain freeways presents different difficulties to the driver. If there is too much information for the driver to comprehend and the primacy of information pertains, two situations must be recognized. One is that all the information input may not be comprehended since the driver's capacity is overloaded. Then the driver may try to identify the most important information and load-shed the information he deems less important. Thus under a high driver task load all the information displayed and required by the driver may not be comprehended. The second case is with the identification of overload points, the information least important at that point can be relocated to a lower driver task load area where the driver has the opportunity to handle the information.

Positive Guidance Concept

Positive guidance has been recognized as an effective means to achieve the safety and operational efficiency of highway facilities by providing the driver sufficient information in the form that he needs to properly accomplish the driving task requirements. Positive guidance is of the greatest benefit to the driver when he must perceive and react to situations and events that occur near each other such that the task load may be high, and the time available to receive and process the information is limited with a reduced margin of error. Positive guidance relates to the guidance subtask and is basically involved with the lane placement and road following.

Detection of an information source by the driver depends on its visibility, conspicuity, and competing sources. It also depends on the expectancy, visual field acuity, a priori knowledge and condition of the device.

Loo (75) performed a study focusing on the relationship between field dependency and the ability to perceive traffic signs in embedded and dis-embedded concepts as measured by verbal reaction times. He determined that field-dependent subjects had longer reaction times to embedded signs and more traffic accidents than did the field-independent subjects. He also determined that extroverts had longer reaction times and more accidents than introverts. Positive guidance properly implemented can reduce the probability of selecting the wrong alternative or provide information to differentiate alternatives. Even after the application of load spreading and primacy of information, there is a problem of evaluating signs from the presented sign information to that information the driver receives. This represents the matching of the sign characteristics and the driver's interpretation ability.

This matching depends on several features. The driver's sign-reading visual behavior is variable. The sign characteristics of size, content, contract, and color are variable. The highway geometry and driver's position, path, and velocity are variable. Many of these factors are driver dependent. The driver can adapt these and his reading behavior in relationship to the importance of the traffic density and interactions, sign relevancy to the driver, and environment. The sign reading behavior of the driver is time shared with the other driving tasks. The driver also does not read all the information displayed by a sign but makes trade-off decisions between amounts of information to be acquired from the sign and time to be spent in performing other driving tasks. The driver reads the sign information until the information he desires is obtained, or he determines the information is not relevant to him. The time required to find the relevant information is dependent on the information location and amount on the sign. The driver cannot discern the nonappearance of relevant information until all the information on the sign has been discerned.

The existing design procedures deal only with the information presentation on the sign, and does not take into account the information receipt by the driver. Since the conventional highway guide sign will remain the principal means of transmitting information to the highway user, it is important that the sign accomplished its intended purpose.

Johnston, et al., (77) reviewed the visual characteristics of the "real" observer using both conventional methods of assessment and an information theory approach. They found that present performance standards do not adequately represent the visual requirements of many practiced tasks. This study suggests that there should be a more systematic approach to the development of design rules based on visual performances of the whole user population rather than only that population which has normal vision. Equally there should be a more purposeful and systematic approach to the imposition of minimum visual standards to ensure that observers maintain a level of visual capability adequate for the designed task.

DRIVER EXPECTANCY AND PREFERENCES

Definition of Expectancy

The traffic system is a complex combination of the driver, his vehicle, the other vehicles using the system, roadway design, traffic laws in effect and ambient physical environment. The driver interacts with these other subsystems for short time periods during which the existing conditions, modified by previous experience, have the potential to modify future behavior. It is the complexity of the driver interactions that make the traffic system so difficult to understand and control. Historically, investigators have tried to resolve this problem by examining each subsystem individually. The emphasis has been placed on the vehicle and roadway with less work done on the driver subsystem, due to its complexity and difficulty to study objectively.

It is generally agreed that a generalization of the driver's expectancy is desirable. Expectancy is an important part of the driver's behavior in the traffic system. Allport (24), in reviewing studies of expectancy by behavioral scientists, assembled 16 propositions. Eight pertinent factors which identify expectancy are summarized in the following paragraphs.

1. Expectancy prepares the individual to perform a response. These preparatory aspects precede, accompany and sometimes outlast the response made. The total behavior happens with greater promptness, speed of execution, and energy.

2. Expectancy serves to develop anticipation for the appearance of the stimulus. This anticipation can be sustained until the stimulus actually appears in the environment.

3. The response the individual makes is exactly the same behavior as that which he has been prepared by expectancy to make. Once the behavioral process has been set in motion by expectancy, it will be consummated unless some unusual circumstances intervene.

4. The behavior implied by the expectancy will be brought to complete performance, and all others, barring some unusual circumstances, will be excluded.

5. The time to react to a stimulus event which the person expects is reduced, whereas reaction time to the unexpected in increased.

6. There is an optimum time interval between that point in time when expectancy initiates a behavior and the required action is initiated. The time interval could be so short that the individual is not adequately prepared. On the other hand, the interval could be so long that anticipation has waned, and preparatory advantages are lost.

7. An expectancy can be developed from a variety of sources. This may include factors associated with the individual, the task in which he is engaged, and the environmental contest in which he operates during the course of his task.

8. Expectancy can involve learning. The meaning of a stimulus and the corresponding behavior it causes, both important aspects of expectancy, are

learned. Since expectancies involve learning, they are subject to processes associated with memory storage, forgetting, and recall.

Dashiell (25) suggested that of the abundance of research on expectancy, there are two general postulates which explain all others. These are that expectancy provides an individual with a readiness to respond a particular way and with a persistence to carry through with the behavior. This idea caused Ellis (26) to give the following operational definition.

Driver expectancy relates to the observable, measureable features of the driver environment which:

(1) Increase a driver's readiness to perform a driving task in a particular manner, and

(2) Cause the driver to continue in the task until it is completed or interrupted.

Factors Affecting Driver Expectancy

The drivers perception of any situation is accompanied by a contextual background of information. This background includes the driver's past experience and training, the driving task, objective and environment and the immediate circumstances. His perception forms a basis for what he does and the expectancies for that behavior. The physical features are as they appear to the driver and as they were designed to exist. Congruence between these two aspects is needed for proper interpretation by the driver.

The factors associated with the driver, the driving task, the environment and the immediate circumstances can be treated as factors of the traffic system. Ellis (26) developed a taxonomy of traffic system factors which involve expectancies at some time. This taxonomy is presented in Figure 3-1.

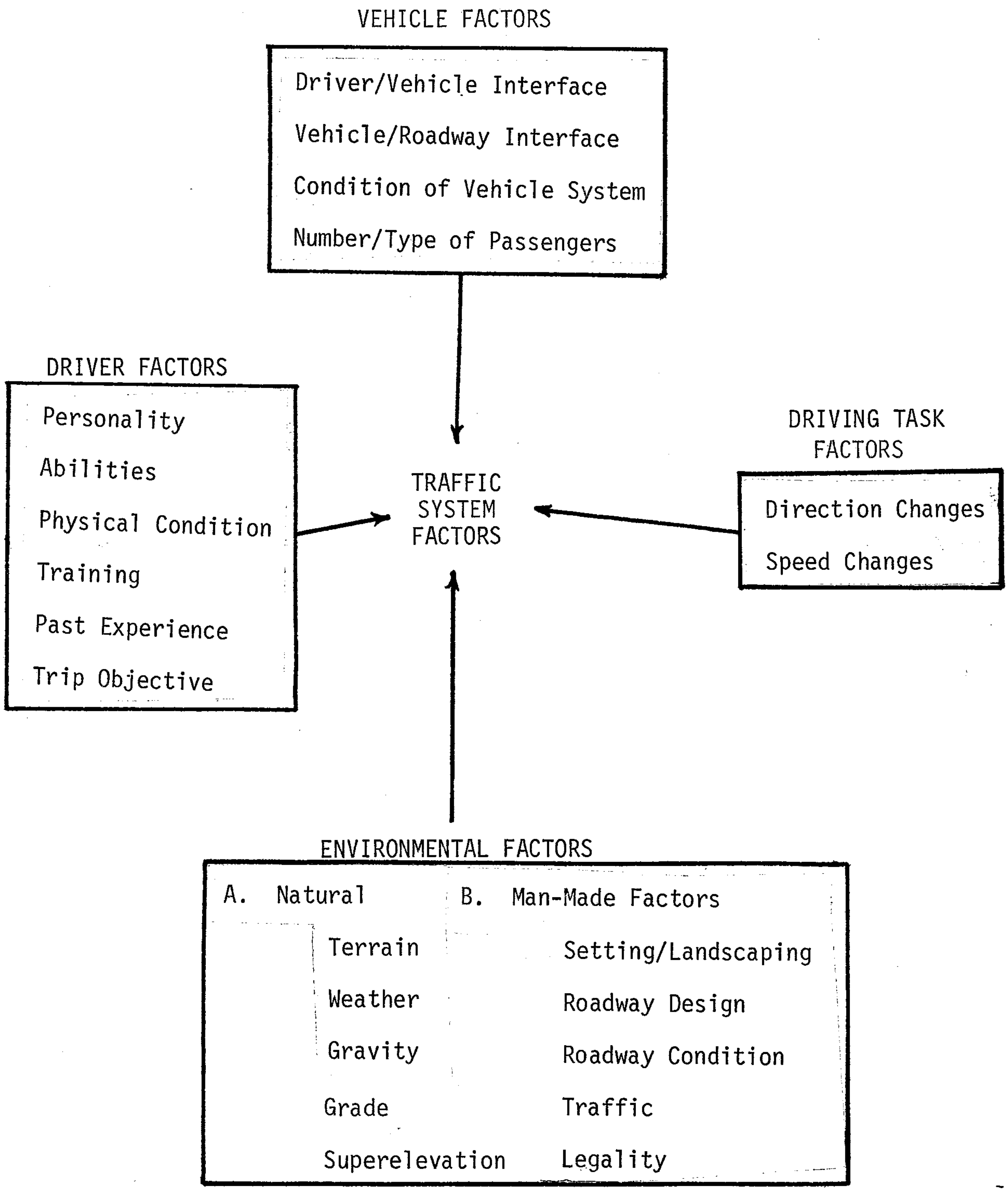

Figure 3-1. Traffic System Factors Involving Expectancies.

Design Philosophy For Driver Expectancy

These and other factors led Ellis (26) to develop a four-point Design Philosophy For Driver Expectancy. The following paragraphs are a summary of his four basic points.

1. Generally the driver feels that the roadway ahead will not mislead or confuse him, and this positive attitude should be confirmed by design.

2. A driver expects in-trip cues and services to guide and assist him in reaching his destination. The driver seeks only information and services he thinks he needs.

3. The driver expects the roadway information system to indicate his location and to provide information which will allow him to follow his desired route. Several items of information should not be presented at the same time or in very close proximity as the driver will have difficulty selecting the relevant information.

4. If there are in-trip requirements for course adjustment, the driver feels that he will be provided the necessary decision making information.

In an effort to facilitate these points, Ellis (26) proposed a Driver Expectancy Design Checklist in the design process. Not only can a checklist serve to jog the designers memory during the design process to needed aspects of the signing system but can also serve as a quality control device after the system is operational to evaluate the design. Roberts and Klipple (74) investigated various ways of presenting lane drop information to motorist. The results of the study indicated that the motorists expectancy was reinforced when exit only panels were placed in conventional signing. Diagrammatics proved to be an excellent method of describing the situation, however, the economics of changing to diagrammatics is prohibitive resulting in modifications being made to conventional signs for short-term solutions to the problem.

Driver Preferences

Information relative to driver preferences in urban freeway guide signing was investigated by McNees and Huchingson (27). and Huchingson, et al. (28). These reports were the source of motorist information requirements from an exhaustive series of studies on the use of real-time motorist information displays and will serve as a guideline for the driver preferences in the state of Texas. The information was obtained from questionnaires administered to 215 motorists at rest stops along Interstates near Dallas and Houston. The objective of the questionnaire was to determine the information which drivers feel would be important to them in making route choice decisions. These results are taken to be driver preferences or can be defined as the methods of information presentation or types of information for which a quantifiable choice by the driver population can be demonstrated over some other method or type. Further information is the results of laboratory experiments. In a study by Jones (73) two types of symbolic presentations of messages conveyed to motorists were investigated. The two types of symbolic presentations were color and shape of signs. It was determined that the use of the interdictory stroke was sufficient to convey a prohibitive message to the motorists.

Hutchingson, et al., (28) describes nineteen separate studies in nine topic areas as they related to Route Diversion and Guidance Variables. In the course of this research several points pertinent to the present study were presented. These points are presented in the following paragraphs.

1. With regards to the type of information a strong preference was observed for information giving the location of upcoming decision points either in the form of a specific distance to that point or some physical marker indicating distance such as next urban center. In addition, a preference was expressed for route numbers and shields and control city-destination

type of information in that order. Only 18.9% of some 676 subjects in three states understood that a three digit interstate number designated a Loop, but 77.7% understood that the word Loop referred to a closed highway around some urban center.

2. With regards to the method or format of messages, almost all subjects preferred no more than 3 to 4 lines of pertinent information to be presented at any time. A combination of route shield and control city yielded a significantly quicker and more reliable selection than any other combination. Signs containing coded information cannot be used without widespread training of the codes and their meaning and should not be used except where this training exists.

MEASURES OF EFFECTIVENESS AND EVALUATION TECHNIQUES

Overview

Numerous studies have been conducted in the past several years to identify and feasibily utilize selected measures of guide-sign effectiveness. As stated previously, two approaches have been instituted employing both laboratory and field techniques. The most apparent deficiency in many laboratory evaluations of traffic signs is the lack of the normal visual cues and distractions of attention that are part of the driving task. Some driving simulators are an exception to this, but even they do not duplicate the task perfectly. Some researchers have incorporated loading tasks into their sign recognition experiments.

Investigations carried out on the road (usually observation of driving behavior) have generally been less adequately designed and conducted than have those done in the laboratory. Field studies of any type tend to involve more uncontrollable variables and unpredictable events than do laboratory studies. Driving experience and potential lack of familiarity with the signs on the part of the subject are often not taken into account. Some subjects may not know a sign simply because they have never seen it, even though it could be a well-designed sign. Expectation plays an important role here.

Historical Data Assessment

The method for both types of evaluation processes can receive initial direction through a review of historical data characteristics associated with a guide sign installation. Two essential classes of historical data should be compiled for analysis.

- Problem data including accident reports/studies and complaints.
- Engineering data including plans and specifications.

Plan view drawings suitable for use as a site diagram may be found in the form of construction plans and/or design specifications; condition diagrams; profile sheets; signing or marking plans; transportation planning maps; topographic maps; or aerial photos. If the available drawings are not cluttered with detail, they can be used directly; otherwise, a "clean" drawing (site diagram) showing the geometric and signing layout of the site should be made. For convenience, the site diagram should be to scale and should incorporate an area both upstream and downstream of the sign location. The profile sheet includes information relating to the sight distance for the signs in this location.

Complaints are usually generated from one of the following sources; media, letters, phone, personal visits, or petition. Usually, either the police or traffic engineering department keeps a file of complaints with a notation of the action taken in response to the complaint. The complaints may be indicators of substantial confusion or misdirection occurring at the location. Former review may be impractical where complaint files are not arranged by location. Instead, scanning through the files or interviewing persons who have made the complaints may provide additional information.

Accident data are usually one of the most important aids to problem identification in that they indicate a failure related to the driver, roadway, or environment. Since accidents are indicators of problems, reviewing the accident data carefully and completely to identify characteristics and trends that could lead to the source of the problem and/or supplement the information derived from subsequent human factors analyses is needed (35).

Measures of Effectiveness

By definition, measures of effectiveness are the dependent variables that indicate the effect of a guide signing treatment. While accident frequency and severity reduction are considered the ultimate criteria in improving safety attributed to guide signing, the use of these measures as dependent variables are difficult and limited. The selection of other measures related to safety and/or operational efficiency should be considered.

These other measures are generally derived from any of the three classes of performance factors indicated below:

- Driver Activity. Driver behaviors and attitudes (e.g., detection, recognition, and preferences) may change as a result of a guide signing treatment. Interviewing is the most common technique for measuring these kinds of variables.
- System Performance. Measures such as traffic flow, delays, and capacities should be considered as dependent variables. This class of variables is particularly important in measuring the effect of signing changes.
- Traffic Performance Measures. This class of variables consists of measurable movements of vehicles including such things as the path, speed, headway, lane changes, lateral orientation, weaves and erratic

maneuvers. Normally, these are the types of measures which you will use. The selection of the proper measure depends on the signing treatment applied and the geometric situation.

Erratic maneuvers in the vicinity of freeway guide sign installations at exits and interchanges commonly are used as criterion measures. Taylor and McGee (33), have defined erratic maneuvers as consisting of any movement that involves a sudden disruption in the continuity of direction and/or speed of the vehicle, or a deviation from the traveled path intended by the geometric design configuration of the section of highway. Erratic maneuvers are used to determine locations where there are signing problems and to study the effect of a signing change at a particular location.

A number of recent studies evaluating the effectiveness of diagrammatic guide signing have yielded definitions of gore area weaving maneuvers. Kolsrud (34) defined two basic maneuvers, "gore weaves" and "exit returns," as being weaves over the painted gore area for exiting and through motorists, respectively. "Weave left" and "weave right" were used to designate directional lane change over the gore extension line approaching a two-lane left-hand exit which appeared to motorists as an interstate bifurcation. Also, lane changing maneuvers approaching the gore area were designated as "risk" and "high risk" maneuvers, depending upon the distance from the gore, when more than one lane was traversed within a specified distance. The "gore weaves" and "exit returns" were used to measure the amount of confusion the driver generated by the diagrammatic sign.

Another diagrammatic signing study by Roberts (35) designated various "unusual maneuvers" by assigning the associated weave-originating and weave-terminating lane designations of vehicles traversing the gore area. A similar designation by Hanscom (1) further separated gore extension line weaves into 300-foot zones. Also included were weaves in a collector-distributor road and weaves over painted gore areas.

Dewar and Ellis (79) examined a simple and inexpensive technique to evaluate traffic sign messages. The technique developed and validated a semantic differential test as a potential instrument for evaluating the messages. The semantic differential test is a paper and pencil test which measures psychological meaning. There are four factors for which scores are obtained. These four factors are; (1) evaluation, (2) activity, (3) potency, and (4) understandability. The individual test scores for each of these factors were related to comprehension and glance legibility. Glance legibility is the ability of the driver to obtain the information needed by glancing at the sign and not taking a lot of time reading the entire sign.

The author found that all four factors were highly correlated to comprehension of symbolic messages, however, they were uncorrelated to glance legibility of verbal messages. Two factors, evaluation and understandability did not correlate with glance legibility of symbolic messages. It was concluded that the semantic differential test is a valid instrument for evaluating comprehension of symbolic sign messages and that it has advantages over other techniques.

Erratic lane change maneuvers have been defined as deviations from an idealized path through an interchange given a particular destination. The theoretical paths must be defined for both existing and through traffic and differ based on interchange geometry (39). A number of other studies to evaluate diagrammatic signing which have depended on interchange area maneuvers have incorporated less specific erratic movement definitions such as "changing lanes suddenly at the exit". Examples of these efforts are Mitchell and Davidson (37), Graham and Volk (38), Wyoming State Highway Department (39), and Orne (40). These studies substantiate the utility of exit area maneuvers as guide signing effectiveness measures.

Conley and Roth (41) made a survey of erratic maneuvers before and after the application of color coding in exit areas. These types of maneuvers by drivers were significantly reduced. Anderson and Pederson (42) investigated the effect of color guidance of traffic, also using erratic maneuvers as an operational measure with essentially the same analysis techniques. Peterson (43) and Roberts (35) have utilized similar techniques involving erratic maneuvers to assess the effects of particular guide signing systems. In a sense, an erratic maneuver can be considered an accident, meaning that it is a maneuver that the driver had not intended to make. Erratic maneuvers are nearly always hazardous, and may result in accidents. Researchers have expressed intuitive confidence that reductions in erratic maneuvers reduce accidents, however little attention has been given to specifying the magnitude of accident potential for given erratic maneuvers reduction in accidents resulting from reductions in erratic maneuvers.

Taylor and Thompson (44) categorized types of erratic maneuvers as follows:

(1) Cross centerline

(2) Cross shoulderline

(3) Vehicle stop (shoulder, median, etc.)

(4) Vehicle back up

(5) Sudden slowing (brake application)

(6) Lane change

(7) Swerve

These erratic maneuvers were combined with other operational measures to estimate the hazard index of a particular roadway site.

The percent of through or exiting vehicles which changes lanes so as to properly position themselves at varying distances from the decision point is referred to as lane positioning. The Connecticut Department of Transportation (45) applied this measure to a diagrammatic signing evaluation and found that existing vehicles moved to the right further away from the gore area with diagrammatic signing. Kolsrud (34) used lane positioning as a measure via the determination of percentages of through and exiting vehicles in each lane at 300-foot intervals in the gore area. Lane positioning was computed for through and exiting vehicles before and after the installation of diagrammatics. Erratic maneuvers and lane positioning are ideal variables to be used in field studies to determine, (1) problem signing areas and (2) the effectiveness of sign changes at specific locations.

Design speed has been defined as the speed determined for design and correlation of the physical features of a highway that influence vehicle operation. Traffic control and guidance signs serve as modifiers to this definition. Leisch (46) presents a new concept in the definition and application of "design speed." He states that the function of design speed is to better meet driver expectations, comply with driver inherent characteristics, achieve operational consistency, and improve driving comfort and safety through a more uniform and balanced design.

The operational measure of this criteria consists of a speed profile technique. Passenger car and truck speeds are chartered along a highway section, taking into account the joint configuration of the various design elements. This procedure identifies the geometric design problem areas and inconsistencies and provides direction for corrective treatments.

Although vehicle speeds are a function of various nonsigning parameters (volume, density, roadway geometry) and are therefore less directly applicable as a signing measure, there are a number of signing studies which use spot speed as the measured variable. Snyder and Crossett (47) and Connecticut (45) used average spot speed in their evaluations of diagrammatic guide signs. No speed effects were seen to result from diagrammatics in either study. Tharp and Harr (48) have developed a procedure whereby spot speeds are calculated from observations recorded by photographic means. The theoretical speed distributions were derived from a mechanistic model which postulates that traffic reacts to a motivating pressure potential which in turn reflects the behavior of traffic traversing a particular section of highway.

The practical applicability of speed as a criterion measure is derived from work by Cirillo (49) relating accidents and differences in speed from the mean speed on interstate highways and on main rural roads, respectively. Based on their work, Kolsrud (34) applied a speed difference measure--the proportion of vehicles traveling 5 mph or slower than the mean speed for all vehicles--in her evaluation of guide signing. A reduction in that proportion of slower vehicles was seen with the diagrammatic signing. In view of the relationships derived by Cirillo, a substantive justification exists for increased application of speed derivatives as signing measures of effectiveness.

Roy (78) studied the effects that sign size, height of installation, and sign legend have on drivers' responses measured by speed, conflict and queueing parameters. The field studies were conducted on a two-lane highway and an interstate highway at four different locations. The conclusions obtained were; (1) speed decreased greater at the two-lane locations for the 0.76 m (30 in) signs than for the 0.91 (36 in) or the 1.22 (48 in) signs, (2) for the interstate locations the 0.91 m (36 in) sign yields better overall responses, (3) installation heights of 0.31 m (1 ft) and 1.52 m (5 ft) signs and sign legends did not indicate any statistical differences in the measured response, and (4) differences in responses by location can be discussed in terms of traffic volume and the motorists' attitudes toward signing in general.

Krzeminski (50) established a correlation between skewed speed distribution and points of high accident potential. This was accomplished utilizing a perception-speed concept of driver responses to a potential accident situation. This concept examined a driver's reaction to a potential hazard based on his personal perception of the hazard and on the forces he had at his disposal to avoid the hazard. The force in question being a speed adjustment. Two types of skewness, frequency distributions that decrease with markedly greater rapidity on one side of the maximum than the other, may be exhibited. Stimpson (51) also employed a similar speed "skewness index," which described the variation in speed distribution, along with lateral placement variance to develop an accident probability model.

In 1969, the Arizona Highway Department (47) conducted a test of one diagrammatic sign at I-10 and Arizona 93. They compared the performance of the new sign with that of the previous sign in terms of reducing the approach speeds of vehicles. Also, they obtained the observations of various professional engineering personnel as well as the opinions of a sample of motorists who drove over the exit ramp. The results of their speed analysis indicated no significant change between the before and after periods. Both the engineering personnel and the drivers using the exit ramp expressed approval of the diagrammatic sign.

Acceleration noise, which is the by-product of speed changes, also serves as a reliable measure of traffic and interactions on roadways. Rowan (52) established that acceleration noise is very sensitive to traffic interruptions which may result from operational deficiencies. This operational parameter was proported to be an invaluable tool in relating the design of a highway facility and the rational relationship to traffic flow variables.

West and Heimbach (53) also utilized acceleration noise as one of several operational variables used in correlating instrumented vehicle responses with the operational characteristics of highways and accidents. The research conducted was based on the premise that inherent roadway operational defects can be determined by investigating the driver-vehicle response to the system, i.e., acceleration noise. Since speed depends on other parameters it is not a good variable to use in evaluating the effects of a signing treatment unless the other parameters can be designed out of the experiment. Without being able to control the other parameters the speeds may be influenced more by these other variables than by the variables being studied namely the signing change.

Drivers' display of brake lights is not a widely used measure of guide sign response. Its more frequent application has been seen in the area of certain warning sign evaluations. However, one diagrammatic signing evaluation (57) did observe a significant increase in brake light applications to result from the signing change.

Headway is also not a commonly recognized measure of guide sign effectiveness. However, Kolsrud (34) applied a "headway violation," as a headway of one second or less, as an indication of accident likelihood in the evaluation of diagrammatic freeway guide signing. This reaction time availability to the motorist suggests hazard potential. Brake lights and headways are variables which may be studied similar to those of erratic maneuvers. In fact brake applications are a form of erratic maneuvers.

Several researchers (58, 59, 60) have used instrumented vehicles to assess a driver's performance in traffic. Some work has also been done (61, 62, 63) on the stimuli that cause particular patterns of control movements. A consensus based on their results indicates that the operational behavior of a driver can be assessed by an analytical study of the frequency and correlation of the three primary control movements: steering wheel, accelerator, and brake. Of these three, it appears that the frequency and magnitude of steering wheel movement may have the greatest significance.

Visual fixation also serves as a measure of effectiveness which requires special equipment for data collection. Eye movements can be recorded the first time a driver is traveling a particular route, and then again when he is familiar with the route. Differences between these two eye movement records should then reflect changes in visual workload caused by a driver's increased familiarity with the route (64). On a navigationally well-signed roadway, the visual workload of the unfamiliar driver should be as close to that of the familiar driver as possible.

Babkov (62) established a relationship between excessive visual input, through increased search and scan patterns in operationally difficult situations, to a reduction in vehicle speed. This involuntary speed reduction result enables the driver to adjust to the volume of incoming visual information relative to what can be mentally processed effectively. Other indicants of driver behavior related to highway operation are psycho-physical in nature. These parameters consist of galvanic skin response, which can be quantitatively and directly measured, and driver comfort which is more qualitatively measured. Instrumented Vehicle studies and visual fixation studies are expensive and the subjects will not tend to operate as they normally will in a non-test situation. They behave as subjects being tested and normal behavior will not be obtained or measured.

Laboratory Versus Field Evaluation

Laboratory tests have several important advantages over field tests in sign evaluation. Laboratory tests are inexpensive. The materials for a study may be prepared from ordinary black and white photographs of a highway, on which artificial sign messages are superimposed. The presentation equipment might include a simple slide projector and a reaction timer. Laboratory tests can be carried out rapidly. Results can be obtained in weeks; a highway study would require months, or even years. Another often overlooked advantage of a laboratory study is that conditions can be controlled. In field studies on the road, drivers are taken as they come. In the laboratory, drivers can be trained to any required level of experience, and precisely the same traffic problem can be presented to each subject. Nevertheless, it is important that results obtained in the laboratory be verified in the field to guard against the possible artificality of the results due to the laboratory situation.

Several noteworthy laboratory evaluations of urban freeway guide signing have been made in recent years. Eberhard and Berger (14) designed a study to determine the graphic sign characteristics that best communicated roadway-interchange and route-guidance information to the driver. Emphasis was placed on (a) developing laboratory sign-testing procedures for determining the effectiveness of signing alternatives and (b) developing analytical techniques for identifying interchange characteristics where graphic guide signs might be required and applicable. The tests indicated that route-guidance was improved significantly by graphic signs than by conventional signs on certain interchanges. Graphic signs also convey relative exit speeds and lane-drop information more effectively.

Berger (63) also developed a series of laboratory techniques to derive empirical data for designing and deploying diagrammatic signs. The proper lane positioning technique was found to be the most effective method for testing the guide signs. This technique proved valuable in differentiating other roadway characteristics that graphic signs can present to the driver. The laboratory results showed that graphic guide signs permitted better route guidance performance than conventional signs at certain complex interchanges; collector-distributor with lane drop, and multiple split ramps.

Zajkowski and Nees (80) performed a laboratory study designed to establish a low-cost reliable laboratory technique for the the evaluation of highway guide signs and to resolve differences in previous laboratory studies with regard to diagrammatic guide signs. The laboratory study consisted of a set of slides for each of the following six types of freeway interchanges. The six types of interchanges were:

1. Lane Drop
2. Multiple-split Ramp
3. Left Ramp Downstream from Right Ramp
4. Two Right Ramps in Quick Succession
5. Major Fork, and
6. Cloverleaf

It was found that response times were consistently longer for diagrammatic signs than for conventional signs. The subjects reported being more confident of and having a preference for conventional signs and the correctness of lane choices was slightly higher for conventional signs than for diagrammatic signs.

Mace, Hostetter, and Seguin (64) conducted laboratory and controlled field studies to evaluate driver performance at exit ramps. Using a driving research simulator and an instrumented vehicle, they studied two variables - information presentation time (the amount of time a sign is readable) and information lead distance (the distance from an exit to the advance information sign place) -

to determine how signing effects the existing maneuver. The results indicate that, if given too much advance warning, drivers tend to pass if impeded; and they find themselved out of position to maneuver early into the deceleration lane. In addition, advance information presented close to the beginning of the gore generally results in an erratic maneuver.

The lack of adequate warning as a contributor to driver indecisiveness at exit areas is cited by Peterson and Schoppert (43). They state that of the comments obtained from their questionnaires, one of the most frequent was "not enough advance warning." Many motorists believed that the signs were either poorly located or were too close to a decision point. This is substantiated by another study (68) where approximately 9% of the drivers interviewed had difficulty finding their way to their destination on the current trip, while 14% had such difficulties in the past. Twenty percent found the traffic signs confusing. One of the most frequent complaints was that signs did not give sufficient advance warning to the driver. Depending on the degree to which the vehicle is instrumented, this type of test is extremely expensive.

The Texas Transportation Institute (23) in conjunction with several state highway departments, conducted a study of highway visual communicatiom systems, using a diagnostic team approach. In addition to developing the diagnostic technique, the study objectives included the identification of problem areas in visual communications and the formulation of recommendations to alleviate them. This technique is extremely useful in site evaluations to determine the possible cause of problems existing at that site.

A similar type study interviewed drivers about their directional signing experience (69). Two interviewing techniques were used: roadwise interviews which were necessarily brief, and off-the-road extended interviews which were more extensive. The roadwise interviews were conducted at locations exemplifying certain signing conditions. The study findings clearly support the existence of certain basic principles of directional signing which, if followed, will help make sign messages of maximum value to motorists. The interview method is extremely useful in obtaining motorist reactions to problem areas and possible solutions to the problem.

Dewar and Ells (67) used three experimental techniques in evaluating the same signs. It was part of a larger project intended to develop and compare several techniques for evaluating roadway signs. The techniques employed involve (a) a controlled experiment conducted on the highway under normal driving conditions, (b) a modified on-the-road measure, and (c) a laboratory reaction time measure. The on-the-road method was considered to be a good technique against which to validate the other methods. The modified on-the-road technique came close to actual driving situations but under different conditions that are less expensive and time-consuming. The reaction time study, while not intended to simulate a driving situation, was designed so the performance could be meaningfully compared to that of the other two techniques.

Dewar and Ells (79) conducted a study of sign message modifications at the Toronto International Airport. This project consisted of a field study (traffic flow), interviews, and laboratory studies. Sign messages at three locations were evaluated. Several sign message alternatives were studied in the laboratory before the modifications were made. Driver opinion and traffic flows were evaluated immediately following the signing changes. The results indicated an improvement in traffic flow at two of the three locations the messages were changed. To adequately evaluate signing systems, either new systems or changes to existing systems, several techniques should be used in conjunction with each other. In this way the results will not be biased based on the techniques used.

Few comparisons have been made between field tests and laboratory tests. One such experiment is that of Desrosiers (68) who conducted an experiment to validate the substitution of laboratory tests in which motion picture techniques were used for field research methods. Results indicated that the laboratory test and the field measure showed essentially the same trends, but mean legibility distances were 5 to 6 times as great in the field test.

Markowitz, et al., (69) report a laboratory study and field study using the same 10 signs. The laboratory study involved the method of signal detection (in which stimuli were presented for a fraction of a second), which provides a pure measure of detectability of glance legibility. The field test was conducted on the road using the Senders' helmet apparatus, which occludes the driver's vision for short periods of time. The findings showed recognizability to be lower in the road test than in the laboratory test.

It appears, then, that laboratory tests may give somewhat different results from on-the-road measures, depending on the particular techniques used. However, more research needs to be done comparing laboratory and field techniques before a firm statement regarding their relative merits can be made.

In summary, the literature on urban freeway guide signing shows many methodological techniques, measures of effectiveness, problems as well as a tendency for such research to examine only one aspect of the sign evaluation process. It appears that a single method will not be adequate but rather that each of the factors involved (e.g., meaning, attention value, legibility-processing time, learnability, influence on driver behavior) requires its own method of evaluation. Some combination of methods may be required to adequately evaluate a sign or signing system.

SUMMARY

Considerable effort has been and continues to be expended in attempts to maximize the effectiveness of expressway and freeway guide signs. The information presented on urban freeway guide signs, both advance and exit direction, serves as the navigational basis for decisions made by the driver. The correctness of these decisions, and the consequent successful completion of the driving task, depends on quick and clear understanding of the message. Proper consideration of the following factors will tend to optimize quick and clear understanding.

(1) Comprehension: The message should minimize all potential sources of misinterpretation and ambiguity. The message should not depend on a high order of logical deduction for its comprehension.

(2) Emphasis: The most important information (needed by most drivers, requiring most immediate decision or whose nonreceipt could have the most adverse effects) should be emphasized by size, location, letter type, color, underlining, or other means.

(3) Rejectability: Without compromising other principal factors, the design of the sign should be such that the information can be quickly rejected by drivers not needing it.

(4) Expectancy: Legend and location should conform to the driver's expectation based on pretrip map planning, a priori information, previously seen signs, and subjective evaluation of the driving situation.

(5) Uniformity: Furnish similar types of information in a similar manner for similar decision situations. Conversely, indicate dissimilar, unusual, or unique situations by furnishing appropriate information in a manner that will indicate that an unusual driving maneuver may be required.

(6) Sign Consistency: Keep the same types of information in the same

general location on sign panels. Keep the same information in the same size insofar as possible.

(7) Repetition: Information should be repeated, sufficiently often, so as to minimize the possibility of a driver forgetting between signs. Also, drivers who have missed one sign (due to noise or lack of attention) should be given a second change.

(8) Legend Consistency: The same information (e.g., route number, name, destination) should be carried on all signs until the need no longer exists. Incremental information (distance to exit) should always be consistent in arrangement and units of measurement.

(9) Exclusiveness: New information should be introduced in a logical manner. No new information should be furnished after initiation of a necessary driving maneuver. No information should be given that does not affect the choice among alternatives in a given decision situation.

The guide signing presently in the Manual On Uniform Traffic Control Devices (MUTCD) cannot fully satisfy the directional information needs of all of the highway users at all times. This is due to the shortcomings of present mapping practices, the variability of possible user trip plans, and the lack of control that the sign designer has over trip plans and maps. These reasons, plus the lack of data as to which maps are used by whom, and how trip plans are formulated, make it exceedingly difficult to conduct an evaluation which will produce a formula for determining the proper message to put on a guide sign.

What is reasonably attainable, however, is the optimization of guide sign messages so that the greatest number of highway users will be served by the sign. An evaluation technique should review the sign messages in the context of human factors principles and thus minimize uncertainity while maximizing usability by all drivers. This will be a guiding principle in evaluating sign messages.

In essence, an evaluation procedure for guide signing, insofar as messages are concerned, is to evaluate the message content of signs for the following:

(1) Applicability of Message Content: The main task in evaluating guide signing is to ensure that the message content of guide signs applies to all drivers using the highway. It is assumed that the guide sign will be directed primarily toward the unfamiliar driver with a map and a simple trip plan.

(2) Absence of Ambiguity: Once a message is deemed to be applicable, a check should be made for ambiguity. Ambiguity occurs where the information is unclear, obscure, has more than one meaning, or creates uncertainity. Hopefully, the process whereby applicability has been determined will eliminate obscurity.

(3) Avoidance of Negative Reasoning: Negative reasoning is the situation where a driver reads a guide sign with a particular destination and, because his destination is not included, reasons that the exit could not possibly lead to his destination. The existance of this potential form of error on the part of the driver should be recognized. Avoid the use of destinations unless they are obvious, and, in the case of equiprobable destinations served by a particular interchange, include both or neither on the sign.

(4) Continuity and Consistency: Continuity should exist, particularly from the advance guide to the exit direction signs. An exit direction sign should never surprise the driver. The legend on the advance guide sign and the exit direction sign must be consistent. Similarly, there should be consistency between all guide signs on the road.

(5) Minimize Uncertainty: For most of the traffic stream, most exist are not in the driver's trip plan. Therefore, the driver's should be able to quickly obtain the information they need and reject all other information.

There are many factors to consider when evaluating guide signing. Each has its own particular merits and method of evaluation. This state-of-the-art review points out many of these evaluation techniques currently being used.

CHAPTER 4

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