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The study results showed that the changeable message signs were effective in providing information to the motorist. Considerable motorist diversion was noted during analysis incidents which were accompanied by a "LANE BLOCKED" display. The signs were highly visible, generally understood, and useful within the constraints of corridor geometry. Lack of understanding of the letter-grade rating scale employed was attributed to the fact that the scale was not anchored to a readily understandable base. Questionaire results showed that a vast majority of the respondents found the system useful.

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EVALUATION OF A CHANGEABLE MESSAGE SIGN SYSTEM ON THE INBOUND GULF FREEWAY

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Research Report 200-1F
Final Report

Vehicular Incident Detection
and
Motorist Information Systems
Research Study No. 2-18-75-200

Sponsored by the
State Department of Highways and Public Transportation
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Federal Highway Administration

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College Station, Texas

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Abstract

This study is concerned with the evaluation of real-time changeable message signs that inform motorists of freeway traffic conditions. Included in the study is an evaluation of the use of a letter-grade rating scale for indicating freeway conditions. Evaluation was accomplished through the use of a questionnaire survey and a traffic operations analysis.

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KEY WORDS: Changeable Message Signs, Motorist Information Systems, Freeway Operations, Motorist Diversion, Letter-Grade Rating Scale

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Summary

In an effort to reduce freeway congestion and improve transportation services in Houston, the State Department of Highways and Public Transportation installed three changeable message signs in the Gulf Freeway Corridor in October, 1973. These signs were designed to provide useful information about freeway conditions. Using the information provided, motorists were able to select alternate routes to their destinations and thus reduce traffic volumes and congestion, especially during incident or lane closure conditions. A uniquely important aspect of the project was the implementation of a letter-grade rating scale which reflected freeway traffic conditions. This report evaluates the operation and effectiveness of the sign project.

Project evaluation was based on data obtained from traffic operations analyses and from questionnaire responses.

The results of this study suggest that changeable message signs are an effective method of reducing urban freeway congestion. They contribute to the reduction in overall delay to the motorist as well as the reduction in total demand on the freeway. Further, they effectively enhance safety by reducing traffic volumes and potential conflicts in the vicinity of incidents and lane closures. Especially important was the significantly positive reaction to the signs and toward the State Department of Highways and Public Transportation for their attempts at reducing congestion. The following specific findings are drawn from the results of this research.

1. The freeway sign was visible and had a high target value (96 percent of the motorists responding to questionnaires had seen the signs).
2. Analyses showed that, during incident conditions, more motorists diverted from the freeway when the sign displayed "LANE BLOCKED" than

when the signs were inoperative. Other analyses showed significant response to "KEEP RIGHT" messages.

3. Messages on the freeway sign (14-inch characters) were legible. Messages on the frontage road signs (6-inch characters) were not legible, probably due more to inadequate bulb brightness than to letter height. Letter spacing and formation on all signs were satisfactory.
4. Sign placement was satisfactory in the lateral direction, except that a few motorists indicated that a freeway sign was difficult to see from the inside (median) lane.
5. Sign locations were satisfactory within the geometric constraints that existed at the time of implementation. Closure of the inbound frontage road and opening of Loop 610E significantly affected the desirability of sign location.
6. The freeway matrix sign performed quite satisfactorily for the intended purpose. Three-line messages proved somewhat constraining in a few instances because the upper line contained the fixed message "FWY CONDITION," leaving only two lines for information display.
7. The motoring public did not satisfactorily learn the letter grade (A, B, C, D, F, X)-freeway condition relationship. This was due, in part, to lack of anchoring of the rating scale.
8. A vast majority of motorists understood the signs and the several messages. Of those who understood, 82 percent used the information.
9. The installation of a similar sign(s) on the inbound Gulf Freeway south of Loop 610 offers promising diversion potential as 43 percent indicated that they would be amenable to diversion at that location.
10. A vast majority of the respondents rated the system "useful" or "very useful." A slight majority indicated that the system could be improved.

11. The analysis of motorist comments indicated that it would be highly desirable to indicate which lane is blocked during "LANE BLOCKED" displays.
12. It was noted throughout the course of the project that one of the most tedious tasks in sign operation was the continuous observation of the closed circuit television. Improvement of this facet of system operation would reduce response time and increase consistency of operation.

In the vehicular incident detection phase of the project, an algorithm has been developed and programmed on the computer for detecting vehicular incidents of urban freeways operating at low volume conditions. Detailed testing of this algorithm awaits the completion of a reliable detection system currently being installed on the north loop of I-610 in Houston. This research will be reported in 1976 within HPR Project 173 entitled "Development and Evaluation of On-Freeway Control Systems and Surveillance Techniques."

Implementation

The results of this research should provide additional guidance in the formulation of plans and specifications of future matrix lamp changeable message signing systems. Promising general locations for providing useful freeway traffic information in major cities are identified with a specific location given for Houston. Daily operational considerations for routine operation of the signs are also provided.

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EVALUATION OF A CHANGEABLE MESSAGE SIGN SYSTEM ON THE INBOUND GULF FREEWAY

Introduction

The Problem

Urban freeway congestion occurs when traffic demand exceeds the capacity of the freeway. According to Everall (1), causes of congestion can be divided into three categories: 1) congestion due to capacity reducing incidents (accidents, stalls, etc.), 2) congestion due to geometric bottlenecks (lane drops, entrance ramps, etc.), and 3) congestion due to construction or maintenance. Capacity reducing incidents are more or less a random phenomena, making them difficult to predict. Effects of geometric bottlenecks are more predictable, as congestion can be expected when freeway volumes reach the known capacity of the bottleneck section. Construction and maintenance activities are generally planned for periods of lower freeway demand but can result in congestion when such activities require a lane closure.

The State Department of Highways and Public Transportation has employed several techniques aimed at reducing congestion on the Gulf Freeway in Houston. These techniques include: accident investigation sites and courtesy patrols to minimize the effect of incidents; and ramp metering and ramp closure to redistribute demand on the freeway. Another concept which has been found to offer benefits to motorists in other cities is that of motorist information systems. These include low power radio systems, telephone call-in systems, and changeable message sign systems. In a continuing effort to further serve the freeway motorist, the State Department of Highways and Public Transportation installed three changeable message

signs in Houston within the Gulf Freeway corridor in October 1973. The Texas Transportation Institute was engaged to develop an operational plan and evaluate the effectiveness of the system within HPR Project 200.

An Approach to Reducing Freeway Congestion

The concept of reducing congestion through the use of motorist information systems is that of providing the driver with sufficient information about traffic conditions on his primary route (the freeway) to allow him to decide when it would be better for him to use an alternate route. An alternate route may be one that will eventually take the driver to his destination, or it may actually be a diversion route, such as a frontage road, to allow the driver to bypass an incident or congestion and return to the freeway at a more favorable location.

Almost all urban freeway corridors have arterial streets or frontage roads parallel to the freeway which operate below their capacity, even during peak periods. One function of a motorist information system is to divert motorists from a saturated freeway to frontage roads and arterial streets that are operating below capacity, and thus more fully utilize the total available capacity in the corridor.

The three changeable message signs installed in the Gulf Freeway corridor are a small part of an overall surveillance, information, and control system, much of which is already operational. These signs employ two basic types of messages -- freeway condition messages and motorist guidance messages. There are two types of freeway condition messages: 1) descriptive ("LANE BLOCKED," "SLOW TRAFFIC," etc.), and 2) letter grades ("FREEWAY CONDITION 'A,'" etc.). Although the descriptive messages have been used effectively in numerous locations, the letter grade rating scale was developed in hopes that motorists would learn the association between letter

grades and certain freeway conditions. If such a rating scale were successful, it would greatly reduce the required message length, and thus reduce the cost of changeable message signs.

Motorist guidance messages were used when the most advantageous course was obvious. For example, if the median lane were blocked by an incident, a KEEP RIGHT message would be displayed. Should an incident occur in the immediate vicinity of the signs, a "USE FRONTAGE ROAD" or "USE NEXT RAMP" message would be displayed to frontage road drivers.

This system of signs was developed for and directed at the familiar Gulf Freeway driver. Therefore, messages indicating alternate routes such as "USE TELEPHONE ROAD TO DOWNTOWN" were not included. It was assumed that the familiar driver would be aware of alternate routes and would only need information regarding the condition of his primary route to make a decision. Further, if alternate routes were displayed on the freeway/frontage road signs, it would probably be necessary to employ an extensive system of static and dynamic trailblazers along the alternate route to guide the motorist to a specific destination (downtown). Such a system was beyond the scope of this project.

The Objectives of the Project and Reported Results

The objectives of the changeable message sign operations were twofold: 1) improve traffic operations, and 2) evaluate sign design and communications techniques.

Traffic Control Objectives -- The traffic control objectives for the changeable message sign system were the same as those for any freeway control or information project. These objectives were:

1) To reduce overall delay to freeway motorists during congested freeway conditions by diverting some motorists to alternate routes;

2) To reduce total demand on a freeway section by diverting frontage road motorists to either a more favorable entrance ramp or to an alternate route; and

3) To enhance safety on the freeway by reducing traffic volumes and potential conflicts, especially in the vicinity of an incident or lane closure.

Sign Design and Communications Objectives -- Sign design and communications objectives were developed to assist in evaluating system effectiveness within the scope of its intended functions. Design objectives included:

1) Determining adequacy of target value;

2) Determining legibility of letters, including size, spacing, and character formation;

3) Determining adequacy of lateral and longitudinal sign position;

4) Determining whether three-line messages are satisfactory for adequate message transmission; and

5) A subjective determination of whether matrix signs in general are desirable with respect to brightness and legibility.

The communications evaluation objectives were:

1) To determine whether motorists would learn a letter grade-freeway condition relationship without a public education program;

2) To determine whether the messages used were understood; and

3) To determine whether the messages used were considered useful by the motorists.

Project Objectives -- The contract objective of HPR Project 200 was

"to complete a cost-effectiveness analysis of a changeable message sign system during the latter phase of the study on 'The Development of Urban Traffic Management and Control Systems'."

Evaluation Methodology -- Two techniques were used to evaluate the changeable message signs. The first was the analysis of changes in traffic flow parameters during periods of selected message display. Freeway volumes and speeds and ramp volumes are input from strategically placed detectors to the IBM 1800 computer in the surveillance center. These data were recorded each time "LANE BLOCKED," "SLOW TRAFFIC," and "OK" messages were displayed on the freeway sign. To assess the effect of voluntary diversion (i.e., that done due to evident congestion), data were obtained, after the signs were removed, during periods when the "LANE BLOCKED" message would have normally been on. These two data sets were then compared to ascertain the portion of the traffic stream diverting as a result of information displayed on the signs.

Questionnaire surveys were the other technique used in sign evaluation. Questionnaires were mailed to drivers observed passing the freeway sign during certain message displays. The questionnaires embraced certain objectives that could not be determined from traffic flow parameters and contained both operations- and communications-oriented facets of system evaluation. These questions sought to obtain motorist input to understandability and usefulness of messages displayed and to determine driver response to and overall evaluation of the changeable message sign system. The analysis of the questionnaires and traffic flow data will be detailed in subsequent sections of the report.

Project Description

The Gulf Freeway changeable message sign project was one of several recommendations presented in a previous systems analysis study by Messer, et al. (2), of the physical and traffic characteristics of the freeway, frontage road, and arterial street systems as they existed in 1971. Subsequent alteration in freeway demand and physical layout had a considerable effect on the operation of the changeable message sign system. Analyses leading to the system development and subsequent influential factors are discussed in this chapter.

Gulf Freeway Corridor Description

The Gulf Freeway in Houston is a six-lane divided facility. The portion of the freeway presently under ramp control and television surveillance extends from the Reveille Interchange inbound toward downtown for 3.5 miles to the Dumble entrance ramp. Overpasses at major arterials and railroad crossings produce a roller coaster effect on the otherwise at-grade facility. As depicted in Figure 1, the inbound frontage road was designed to be discontinuous at the railroad crossings near the Mossrose and Dumble entrance ramps. In addition, an at-grade railroad crossing of the frontage road was permitted between Telephone Road and Dumble Street.

The surface street system in the Gulf Freeway corridor is composed of several skewed arterial and collector grid patterns (Figure 2). Trip origins for motorists using the inbound freeway occur mainly in the Pasadena area, along the southern part of the freeway, and in southern Houston. This traffic has four basic destination points: 1) the CBD, 2) northern Houston, 3) the ship channel area, and 4) major generators adjacent to the Gulf Freeway, e.g., the University of Houston.

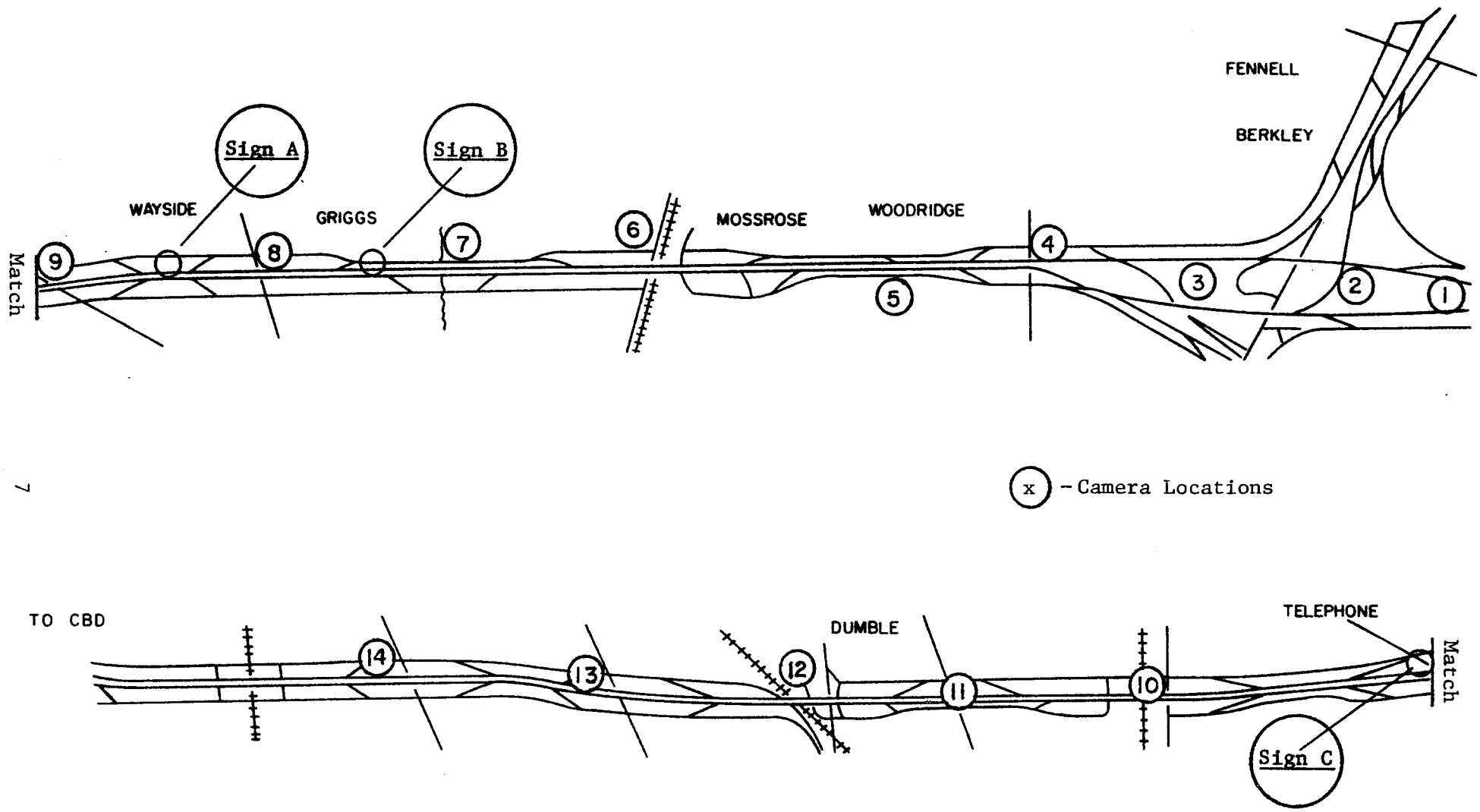

Figure 1. Gulf Freeway and Frontage Road Layout

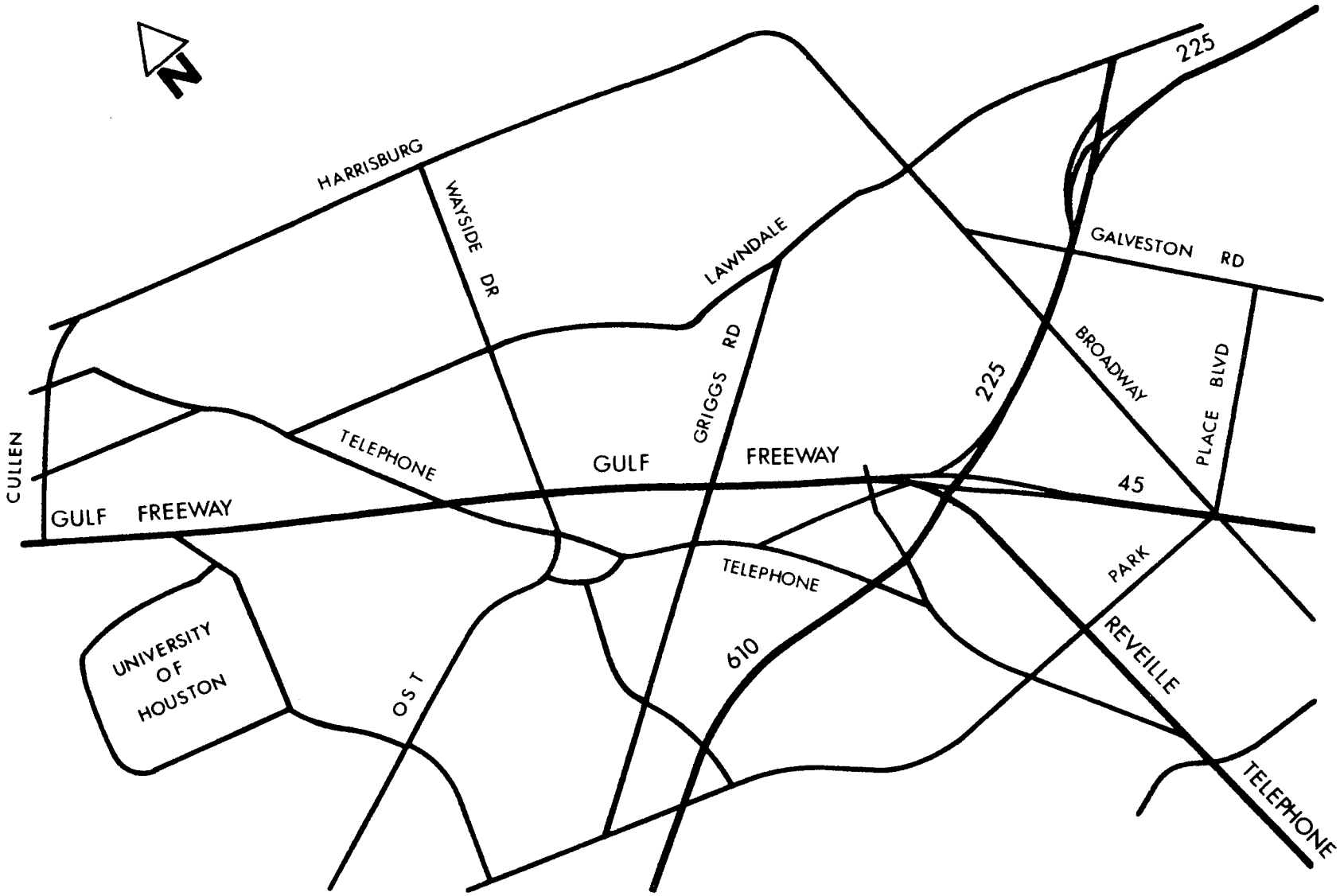

Figure 2. Inbound Gulf Freeway Corridor

1971 Systems Analysis

As mentioned previously, recommendations from an earlier study by Messer, et al. (2), formed the basis for the design of the changeable message sign system. That study revealed that 50 percent of the inbound incidents occurred downstream of Telephone Road. Further, 28 percent of the inbound incidents occurred between the Telephone exit ramp and the Dumble entrance ramp.

Based on travel time savings and available capacity, Telephone Road ranked highest as an alternate route. Therefore, the vicinity of Telephone was chosen as the optimal location for an on-freeway real-time information display. Ranking of entrance ramp locations for information displays revealed that the Griggs, Wayside, and Telephone entrance ramps were the "best" locations, based on demand, diversion capability, and sight distance indices.

The results of the 1971 systems analysis provided a priority ranking for the numerous components of the recommended motorist information system. Those elements which received the highest priority for implementation were:

1) The installation of changeable message signs at the Griggs and Telephone entrance ramps, and
2) The installation of a changeable message sign on the inbound Gulf Freeway near the Wayside entrance ramp such that the freeway and Wayside ramp traffic could make effective use of the information provided. This sign could also be used for diversion of traffic off the freeway onto the frontage road to bypass congestion between the Telephone exit ramp and the Dumble entrance ramp.

Project Design

Locations of the three changeable message signs are shown in Figure 1. One sign (Sign A) was placed on the right shoulder of the freeway north of Wayside so as to be visible to both freeway traffic and Wayside entrance ramp traffic (Figure 3). Two smaller signs (Signs B and C) were placed, one each, at the Griggs and Telephone entrance ramps (Figures 4 and 5).

Two major construction projects had a significant effect on the success of the sign operation. The opening of Loop 610E over the Houston ship channel provided a very important new alternate route to the inbound Gulf Freeway corridor. In addition, the loop reduced the volume of traffic using the Gulf Freeway bound for east and northeast Houston, especially that traffic bound for the ship channel area. By providing a new alternate route and reducing the freeway congestion, the new I-610E Loop undoubtedly reduced the potential effectiveness of the changeable message signs from that projected in 1971.

The inbound frontage road was closed at Lombardy for the construction of a frontage road underpass of the HB&T railroad switching yard. Although this underpass will eventually provide excellent frontage road operation in this section, the construction eliminated possible diversion around the incident-prone Lombardy overpass.

Sign Design -- The two facets of sign design, physical and message design, were considered interdependently. Length of message was dependent on the length of the bulb matrix and vice versa. Therefore, it was necessary to optimize message length vs. cost of construction.

The first step in sign design was the development of the required messages. An extensive study of driver information needs and preferences

Figure 3. Sign A -- Freeway Changeable Message Sign

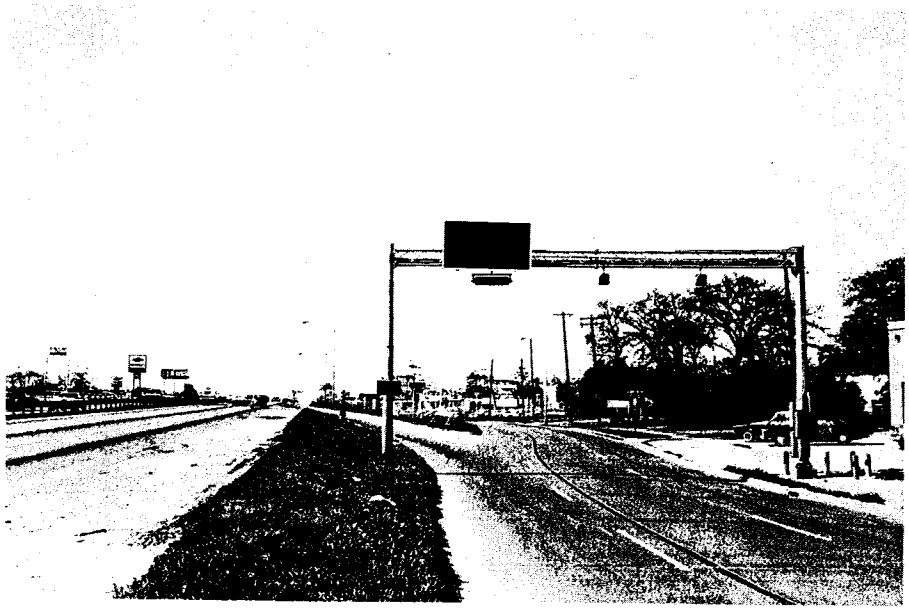

Figure 4. Sign B -- Griggs Entrance Ramp Changeable Message Sign

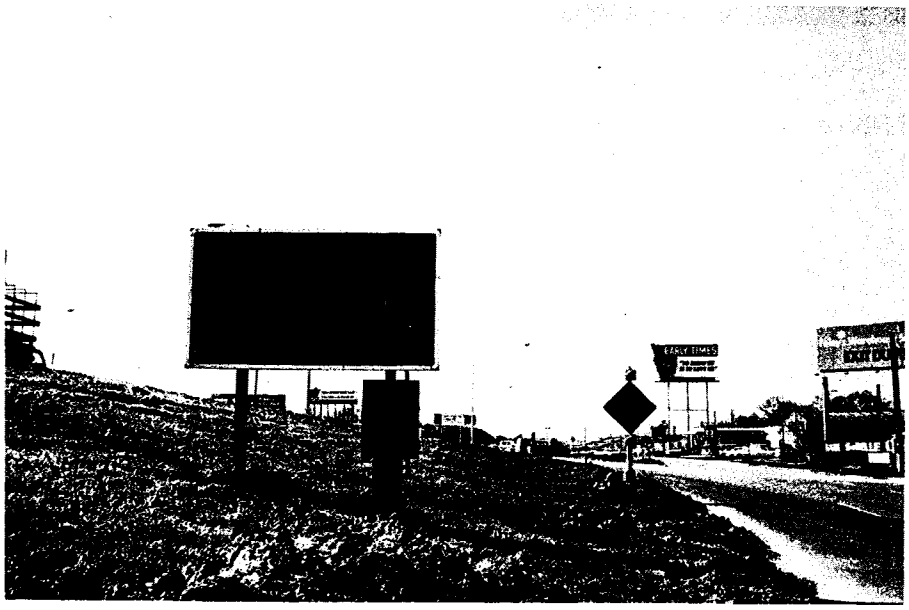

Figure 5. Sign C -- Telephone Entrance Ramp Changeable Message Sign

was conducted by Dudek, Messer, and Jones in 1970 (3, 4). That study revealed that qualitative measures (location and length of congestion and degree of congestion) were preferred to quantitative measures (average speed and travel time). On this basis, messages were selected to reflect these qualitative measures. In addition, selected motorist guidance messages were included for use in certain situations which will be discussed later.

All three signs were designed to contain the capability of displaying various combinations of the two types of qualitative messages and certain motorist guidance messages. It would have been desirable for research purposes to have the capability of displaying many different messages corresponding to the many combinations of conditions, distances, etc., possible in the freeway environment. However, at the time the system was developed, the existing technology in changeable message sign electronics and associated costs virtually dictated a fixed number of messages of four per line. Above that level, the cost of additional messages per line exceeded the funding available for the project. Therefore, the signs were designed to display a maximum of four messages per line. Included in the system design was the capability of adding two messages per line or removing a particular message from the sign memory and replacing it with an alternate message. However, as the existing messages satisfactorily served the intended function, this exchanging of messages was not necessary during the course of the research. Table 1 shows the messages chosen for use in each sign. The upper line of each sign displayed a static message of "FWY CONDITION" which was displayed when the sign was operating.

To supplement the degree of congestion descriptors ("OK," "SLOW TRAFFIC," "LANE BLOCKED"), a series of letter grades forming a rating scale was

Table 1

Description of the Sign Messages Used on
the Gulf Freeway Changeable Message Sign System

Degree of Congestion	Location and Length of Congestion	Motorist Guidance	Letter Grade Rating Scale
Sign A (On Freeway)			
OK SLOW TRAFFIC LANE BLOCKED	3 MI. AHEAD 2 MI. AHEAD 1 MI. AHEAD	KEEP LEFT KEEP RIGHT	A, B, C, D, F, X
Sign B (Griggs Entrance Ramp)			
OK SLOW TRAFFIC LANE BLOCKED	3 MI. AHEAD 2 MI. AHEAD 1 MI. AHEAD	USE FRONTAGE ROAD	A, B, C, D, F, X
Sign C (Telephone Entrance Ramp)			
OK SLOW TRAFFIC LANE BLOCKED	3 MI. AHEAD 2 MI. AHEAD 1 MI. AHEAD	RAMP CLOSED USE NEXT RAMP	A, B, C, D, F, X

developed (Table 1). These letter grades were designed to correspond to certain freeway conditions and were displayed on the same line with "FWY CONDITION." Specific display criteria will be discussed in the section on project operation.

The intent of the use of the letter grade rating scale was to develop a low-cost changeable message sign, as the cost of matrix signs was related to the number of characters in each matrix insert (i.e., longer inserts cost more).

If the degree of congestion descriptor could be reduced from eleven characters ("LANE BLOCKED") to one character ("X"), then one line of a matrix sign could be eliminated or greatly reduced in length.

Motorist guidance messages were included for use when the "best" action for the unaware motorist was apparent to surveillance center personnel. For example, for an incident blocking the median lane of the freeway, a "KEEP RIGHT" message would be displayed. Other motorist guidance messages were self-explanatory. A summary of messages available on each sign is shown in Table 2.

The original design and specifications of the three signs called for matrix inserts that would accommodate the messages to be displayed. The upper line of each sign contained the fixed message "FWY CONDITION" and a single changeable module capable of displaying any single character or number. Middle and lower line inserts were to be 13 characters in length. Figure 6 shows the original sign design.

In the manufacture of the sign, however, the builder chose to fabricate all of the matrix inserts in each sign the same length. Therefore, the signs, as installed, had the configuration shown in Figure 3.

Table 2

Messages Available on Changeable Message Signs

	Sign A	Sign B	Sign C
Upper Line	FWY CONDITION A B C D F X	FWY CONDITION A B C D F X	FWY CONDITION A B C D F X
Middle Line	OK SLOW TRAFFIC LANE BLOCKED KEEP LEFT	OK SLOW TRAFFIC LANE BLOCKED USE	OK SLOW TRAFFIC LANE BLOCKED RAMP CLOSED
Lower Line	3 MI AHEAD 2 MI AHEAD 1 MI AHEAD KEEP RIGHT	3 MI AHEAD 2 MI AHEAD 1 MI AHEAD FRONTAGE ROAD	3 MI AHEAD 2 MI AHEAD 1 MI AHEAD USE NEXT RAMP

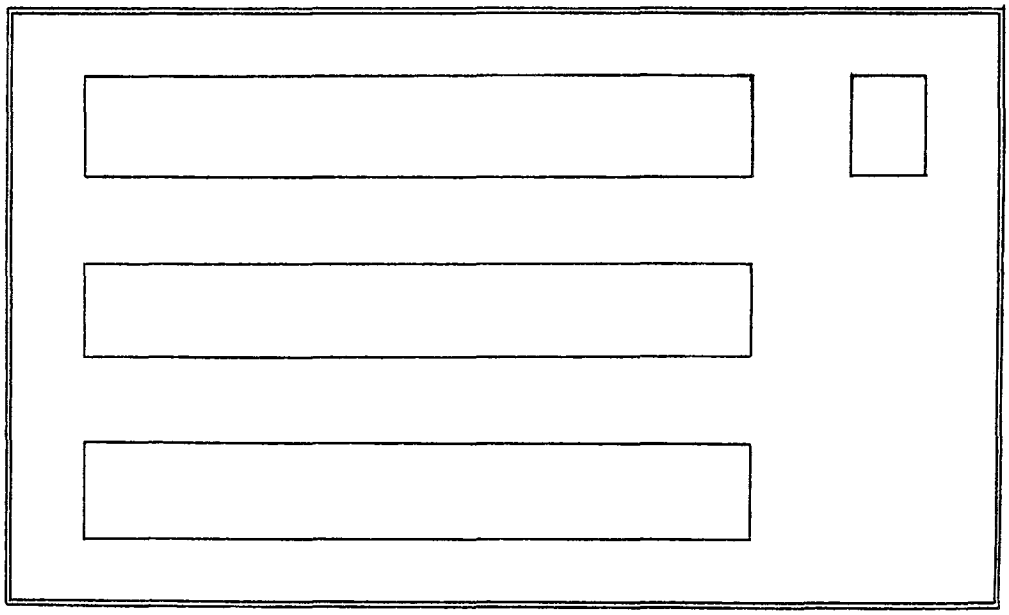

Figure 6. Original Sign Design

This manufacturer's change yielded an upper line of 15 modules in length -- 12 modules of fixed message, 2 blank modules, and one changeable module. The middle and lower line inserts, as fabricated, contained 14 and 15 lamp modules, respectively. The middle line of each sign contained one blank module to yield 15 modules on each line of each sign. Although it would appear that these additional lamp modules would provide added flexibility, the messages displayed during the study did not require this additional space, and thus the extra lamp modules were used only as replacement parts.

Sign A was composed of three matrix inserts, each providing 14-inch letter heights. These 14-inch letters formed by a 25-watt lamp matrix had a legibility distance of 700 feet. This legibility distance was based on 50 feet of legibility distance per inch of letter height, a common standard used for highway signs. The three-line matrix sign installed in a dark green facia had overall dimensions of 8.7 feet by 22.2 feet. Sign A was mounted approximately eight feet from the ground on steel I-beams with

breakaway bases.

Signs B and C were identical in configuration to Sign A, but contained matrix inserts that produced 6-inch characters. These six-inch letters had a theoretical legibility distance of 300 feet based on the legibility distance formula mentioned above. However, the use of this formula requires an acceptable contrast ratio, that relationship between the brightness of the object (the message) and the brightness of the background (the sign). The six-watt bulbs used to form the message did not provide enough brightness to give an acceptable contrast ratio; thus, the signs were legible only at very short distances (see Figure 4). Therefore, due to their ineffectiveness, Signs B and C were turned off in February 1975. Both signs had overall dimensions of 3.6 feet by 6.5 feet. Sign B, located at the Griggs entrance ramp, was mounted on an overhead sign bridge. Sign C was mounted on I-beams with breakaway bases at the Telephone entrance ramp. Complete specifications for all signs can be found in Appendix A.

Sign Control -- Sign control was accomplished remotely through the use of a sign control panel (Figure 7) in the surveillance center. Activation of a particular message was accomplished by pressing the button corresponding to that message, setting the sign selector switch, and pushing the "transmit" button. Confirmation that the message was received at the sign was achieved when the message button was illuminated. Further confirmation was available through closed circuit television monitoring of the message actually displayed.

Communication between the signs and the control panel was accomplished via a closed circuit television cable composed of 50 twisted pairs of AWG #22 copper wire and several coaxial video cables. Commands were

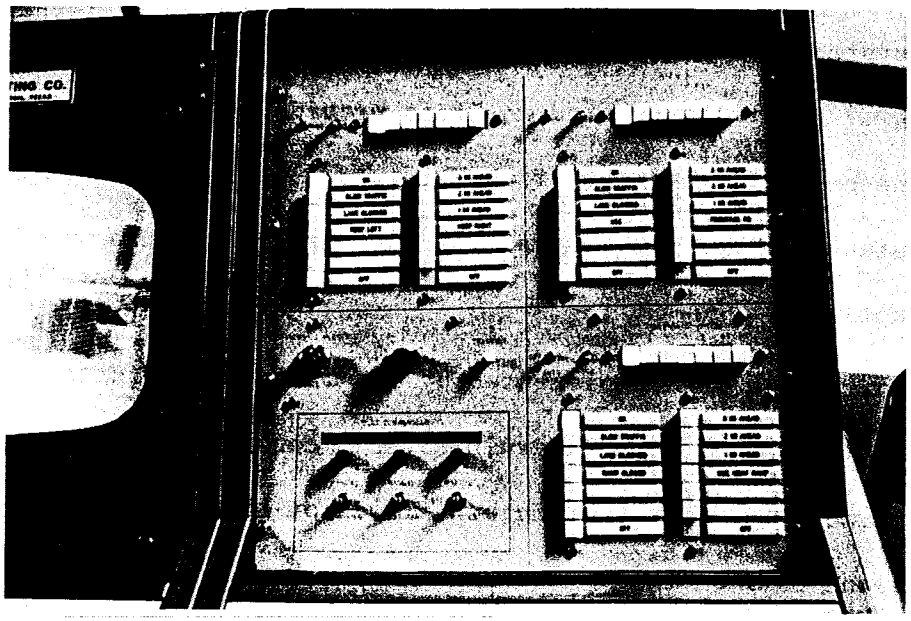

Figure 7. Sign Control Panel

transmitted using time division data link multiplexers which were shared with other surveillance and control functions. Commands were demultiplexed at each sign; confirmation signals were demultiplexed at the control center.

Project Operation

Operational strategy of the changeable message sign system was composed of two parts, the detection of congestion and the selection of appropriate messages for display. As message display criteria were highly dependent on the cause of congestion, knowledge of congestion type and location was mandatory for appropriate message selection. Recurrent freeway bottleneck congestion required different messages than did congestion due to a capacity-reducing incident. This section deals with the procedures followed in the operation of the sign system.

The detection of congestion was accomplished through the use of several

redundant systems. A fourteen-camera closed circuit television (CCTV) system with 17 centrally-located monitors provided real-time observation of a five-and-one-half-mile section of the freeway. Continuous monitoring of this system provided for minimal response time to freeway incidents or other congestion.

CCTV monitoring was complemented by two computerized data input sources in the control room. A Safety Warning System consisting of a buzzer and light alarm indicated that traffic had slowed or stopped at one or more of three locations on the freeway. In addition, the illumination of one or more of a system of eleven lamps on a large scale map of the freeway indicated the slowing or stoppage of traffic at a particular location. These two systems provided control room personnel with additional assistance in the detection and location of congested conditions.

It would have been plausible to develop a data acquisition and control system to provide the capability of computer control of the changeable message signs. Loop detectors on the freeway could transmit data to the control center for analysis by the computer. Based on the analysis of these data, the computer could select the appropriate message(s) and transmit commands to the changeable message signs.

Detailed message display criteria were developed to provide for the operation of the changeable message signs. The logic used was in line with the concept of providing the motorist with information about conditions downstream. Message selection was based on prevailing conditions at Cameras 7 through 14 on the CCTV system. Display criteria for slow and ok conditions are shown in Table 3.

Display criteria for lane blocked conditions varied somewhat from slow

Table 3

Display Criteria for Slow and OK Conditions

Sign A				
At Sign				
Camera 8	Cameras 9-11	Cameras 12-13	Camera 14	Display
OK	OK	OK	OK	OK
OK	OK	OK	Slow	Slow 3 Mi Ahead
OK	OK	Slow	--	Slow 2 Mi Ahead
OK	Slow	OK	OK	Slow 1 Mi Ahead
OK	Slow	Slow	--	Slow
Slow	OK	OK	OK	OK 1 Mi Ahead
Slow	Slow	OK	OK	OK 2 Mi Ahead
Slow	Slow	Slow	OK	OK 3 Mi Ahead
Slow	OK	OK	Slow	(Letter A-F Only)
Slow	OK	Slow	OK	(Letter A-F Only)
Slow	--	Slow	Slow	(Letter A-F Only)

Sign B				
At Sign				
Cameras 7-8	Cameras 9-10	Cameras 11-13	Camera 14	Display
OK	OK	OK	OK	OK
OK	OK	OK	Slow	Slow 3 Mi Ahead
OK	OK	Slow	--	Slow 2 Mi Ahead
OK	Slow	OK	OK	Slow 1 Mi Ahead
OK	Slow	Slow	--	Slow
Slow	OK	OK	OK	OK 1 Mi Ahead
Slow	Slow	OK	OK	OK 2 Mi Ahead
Slow	Slow	Slow	OK	OK 3 Mi Ahead
Slow	OK	OK	Slow	(Letter A-F Only)
Slow	OK	Slow	OK	(Letter A-F Only)
Slow	--	Slow	Slow	(Letter A-F Only)

Sign C			
At Sign			
Camera 9	Cameras 10-12	Cameras 13-14	Display
OK	OK	OK	OK
OK	OK	Slow	Slow 2 Mi Ahead
OK	Slow	--	Slow 1 Mi Ahead
Slow	OK	OK	OK 1 Mi Ahead
Slow	--	Slow	(Letter A-F Only)
Slow	Slow	OK	OK 2 Mi Ahead

conditions. The "LANE BLOCKED" message had priority over other messages and letter grades. Thus, if Slow conditions existed one mile ahead, and lane blocked conditions existed three miles ahead, "LANE BLOCKED, 3 MI AHEAD" was displayed. Logic for display of "LANE BLOCKED" messages is shown in Table 4.

Speed was a major criterion for the display of the various letters forming the rating scale as given in Table 5. Peak, off-peak, and wet weather conditions warrant different letter grade displays. Following is a qualitative discussion of the letter grade designations shown in Table 5.

Dry Pavement

A -- Volume is light to moderate, speeds are high, there is no restriction to flow, very little interaction between vehicles. Travel times are not affected by traffic. Use with message OK.

B -- Peak Period. Volume is moderate to heavy, speeds are high, but there is some restriction to flow, some interaction between vehicles. Travel times are slightly higher than desired. Use with message OK.

Off-Peak Period. Volume is light to moderate, speeds are generally high, but slower at specific locations downstream because of entering traffic, trucks, spilled loads, etc., considerable interaction between vehicles in the affected area. Total travel times are slightly higher because of the delay in the affected area. Use with message SLOW - 1 MI, 2 MI, or 3 MI AHEAD; or with OK - 1 MI, 2 MI, or 3 MI AHEAD (See Table 3).

C -- Peak Period. Volume is heavy, speeds are moderate, but smooth. There is restriction to flow, but few brake lights. Travel times

Table 4

Display Criteria For Lane Blocked Conditions

Sign A				
Camera 8	Cameras 9-11	Cameras 12-13	Camera 14	Display
--	--	--	Incident	LANE BLOCKED 3 MI AHEAD
--	--	Incident	--	LANE BLOCKED 2 MI AHEAD
--	Incident	--	--	LANE BLOCKED 1 MI AHEAD
Incident	--	--	--	LANE BLOCKED

Sign B				
Camera 8	Cameras 9-10	Cameras 11-13	Camera 14	Display
--	--	--	Incident	LANE BLOCKED 3 MI AHEAD
--	--	Incident	--	LANE BLOCKED 2 MI AHEAD
--	Incident	--	--	LANE BLOCKED 1 MI AHEAD
Incident	--	--	--	LANE BLOCKED

Sign C			
Camera 9	Cameras 10-12	Cameras 13-14	Display
--	--	Incident	LANE BLOCKED 2 MI AHEAD
--	Incident	--	LANE BLOCKED 1 MI AHEAD
Incident	--	--	LANE BLOCKED

Table 5

Letter Grade Display Criteria

Dry Pavement	
Freeway Speed	Letter Grade
45+	A
40-44	B
35-49	C
30-34	D
25-29	F
24 or less	X (Lane Blocked

Wet Pavement	
Freeway Speed	Letter Grade
45+	B
40-44	C
35-39	D
25-34	F
24 or less	X (Lane Blocked)

are higher than desired. Flow rates are at a maximum. Use with message OK.

Off-Peak Period. Volume is light to moderate, speeds are high in some sections, low in other sections, considerable interaction between vehicles in the affected area. Total travel times are greatly higher because of the delay in the affected area. Use with messages SLOW - 1 MI, 2 MI, or 3 MI AHEAD; or with OK - 1 MI, 2 MI, or 3 MI AHEAD (See Table 3).

D -- Peak Period. Volume is heavy, speeds are moderate, operation ragged with brake lights. There is restriction to flow. Travel times are higher than desired. Use with message SLOW.

Off-Peak Period. Volume is moderate, speeds are moderate or low in most sections. Considerable interaction between vehicles. Total travel times are high. Use with message SLOW - 1 MI AHEAD or OK - 3 MI AHEAD.

F -- Peak Period. Volume is heavy, speeds are low to moderate, operation is stop-and-go with shockwaves. Travel times are high. Use with messages SLOW or OK - 3 MI AHEAD.

Off-Peak Period. Volume is moderate to heavy, speeds are low in most sections. Travel times are high. Use with messages SLOW or OK - 3 MI AHEAD.

X -- Peak Period or Off-Peak Period. Use when one or more freeway lanes are blocked. Use with message 1 MI, 2 MI, or 3 MI AHEAD.

Wet Pavement

Replace level A with level B,

Replace level B with level C,

Replace level C with level D, and

Keep level F and X the same as before.

Project Cost

The initial capital investment for the changeable message sign project was $80,000. Purchase cost of the three signs was $24,848, and material, erection, and wiring cost $55,152.

Annual maintenance and power costs were tabulated for the 1974 calendar year. During that year, maintenance costs were $3,562 plus approximately $150 in parts (5). Maintenance rate was approximately $500 per maintenance day, including the cost of a truck and a three-man crew. Power costs for Calendar Year 1974 totaled $103 (6).

Lease of the control panel and multiplexing equipment cost $7,235 in 1974. The cost of manpower to operate the system was estimated to be $7,200 per year. This operating cost was based on the requirement that two men be stationed in the control room at an annual cost of $14,400. As it is possible for one man to operate the remaining elements of the control and surveillance equipment, it was necessary to allocate the cost of the additional man to the changeable message sign project. Although he assisted regularly in the other control functions, it was mandatory to have him available to operate the signs.

Assuming a 10-year life of the system and an interest rate of 7.5 percent, the annual cost of the installation would be approximately $30,000, as shown below. Due to influencing factors outside the control of the project, a cost-effectiveness evaluation would not have been meaningful.

Capital Costs		Annual Cost
Purchase	$24,848	(i = 7.5%, n = 10 yrs.)
Installation	55,152	
Subtotal	$80,000	$11,656
Annual Costs		
Maintenance		
Labor	$ 3,562	
Parts	150	
Operating		
Power	103	
Personnel	7,200	
Control	7,235	
Subtotal	$18,250	$18,250
	Total Annual Cost	$29,906

Data Collection and Reduction

As mentioned previously, evaluation of the changeable message signs was planned based on changes expected to occur in traffic characteristics and on information obtained through questionnaire surveys. Many factors influenced the study results, some of which were beyond the control of the project as has been previously described. This chapter deals with the data collection and reduction procedures followed in the study.

Traffic Characteristics

Changes in traffic volumes on the inbound Gulf Freeway were the primary operational measures of effectiveness of the changeable message signs. Specifically, changes in the proportion of traffic exiting at Telephone Road were considered most important. Initially, analysis of volume changes at the Griggs and Telephone entrance ramps was planned, but due to the low legibility of these signs, those analyses were discontinued.

The data acquisition and control system computes volumes, speeds, and occupancy based on input from detectors in the main lanes of the freeway and on the entrance and exit ramps. Traffic flow parameters are shown in one-minute summaries and are retrievable within a twelve-hour period. These parameters, primarily traffic volume, were analyzed to ascertain the effect of the changeable message signs on traffic flow. Other influential factors noted previously (frontage road closure and opening of Loop 610E) were studied to determine their respective effects on freeway volumes. To accomplish this task, "before" and "after" volumes were compared.

Once the effects of these two factors had been identified, the effects of the signs and voluntary diversion could be assessed. To reiterate, of all the motorists performing the intended maneuver (exiting at Telephone

Road), it was conjectured that a portion of the exiting traffic was doing so because congestion was evident instead of because of the sign message. To ascertain the extent of voluntary diversion, traffic volumes on the exit ramp were recorded during "LANE BLOCKED" message displays and during similar conditions after the signs had been removed. The difference between total diverted traffic and the percentage of voluntary diversion was the percentage diverting due to the sign. Results of these analyses will be presented in the chapter on project evaluation.

Questionnaires

Questionnaires designed to measure motorists' attitudes regarding the changeable message signs were distributed to motorists observed passing the freeway sign. These questionnaires were patterned after questionnaires developed in previous research studies conducted on the Gulf Freeway (7) and were distributed under various sign message and traffic flow conditions. Three sets of questionnaire studies were conducted, the procedure of which is discussed in the following paragraphs.

A study was initiated by recording license plate numbers of vehicles observed passing the freeway sign during certain message displays (Figure 8). Names and addresses of vehicle owners were obtained from Texas Motor Vehicle Registration through the State Department of Highways and Public Transportation. Questionnaires were then mailed to vehicle owners requesting that they fill them out and return them in the envelope enclosed. A copy of the three questionnaires and the accompanying cover letter may be found in Appendix B.

Returned questionnaires were keypunched and tabulated using a frequency count program. The output of this program provided a tabulation of responses given for each study individually and for each set of studies. In addition,

Figure 8.

Data Collection in Progress

any comments that the respondent made were recorded. Those comments, some very valuable, may be found in Appendix C.

A total of 2721 questionnaires were mailed for the 39 studies that were conducted (8 studies for Questionnaire "A," 23 for Questionnaire "B," and 8 for Questionnaire "C"). Of that total, 752 were answered and 168 were undeliverable, giving an effective response rate of 29.4 percent. Table 6 shows totals and response rate for each questionnaire survey.

Within the Questionnaire "B" studies were several studies designed to determine whether motorists' responses varied with traffic condition. Conceivably, a motorist viewing the sign under heavy traffic conditions might feel the signs are more useful than a motorist breezing along and having no need for the information displayed. The results of these comparison studies will be discussed in detail in the next chapter.

Table 6

Questionnaire Survey Totals and Response Rates

Questionnaire	Number of Studies	Mailed	Undeliverable	Answered	Response Rate
A	8	475	12	138	29.8%
B	23	1735	112	475	29.3%
C	8	511	44	139	29.8%

Evaluation of Study Results

Analysis of traffic flow parameters and questionnaire responses revealed that the freeway changeable message sign (Sign A) was both effective and useful. Responses to individual questions varied, but the overall reaction by the motorists queried was favorable. This chapter details the results of both the traffic flow and questionnaire evaluations.

Traffic Operations

Volume counts tabulated for the inbound freeway main lanes and for the Telephone Road exit ramp during "LANE BLOCKED" displays revealed that a significant number of drivers diverted. Although several studies were conducted, a typical incident recorded will illustrate driver response. At 1:19 p.m. on February 6, 1975, an accident occurred in the median lane approximately one mile downstream of the freeway sign and remained there for eight minutes (Figure 9). A 40-minute time period (five 8-minute

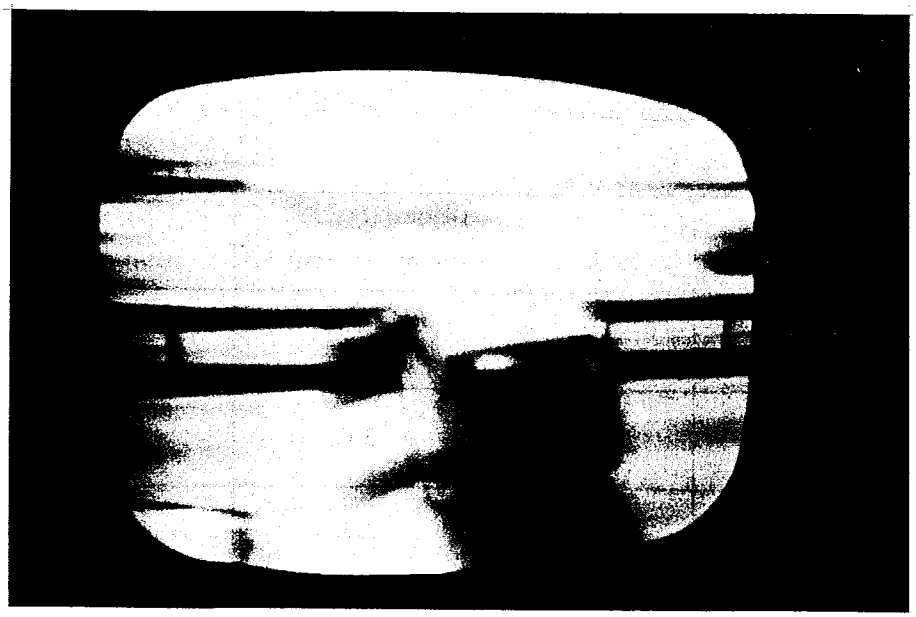

Figure 9. View of Analysis Incident on Closed Circuit Television Monitor

intervals) centered around the incident period was analyzed. Throughout the duration of the incident, the following message was displayed:

FWY CONDITION X
LANE BLOCKED
1 MI AHEAD (KEEP RIGHT)

The two lower line messages were alternated at about one-minute intervals. The volumes shown in Table 7 reflect the changes that occurred at the beginning and end of the incident.* In general, freeway volumes decreased almost 50 percent while ramp volumes increased over 250 percent. A corresponding increase in freeway volume and decrease in ramp volumes was noted after the "LANE BLOCKED" message was removed.

During the time periods analyzed before and after the incident conditions, the exit ramp volumes accounted for an average of 6.6 percent of the total cross section volume. However, during the incident period, 32.3 percent of the total freeway cross section traffic used the exit ramp. This figure indicates that a large portion of the freeway motorists considered diversion to an alternate route a viable alternative.

As mentioned previously, it is probable that some portion of those drivers who diverted did so voluntarily; that is, because of evident congestion, and not because of the sign. To ascertain approximately how much diversion was voluntary, similar data were collected during incident conditions after the signs had been inoperative for several weeks. To illustrate the level of voluntary diversion, an incident which occurred on June 20, 1975 at 3:54 p.m. near the Lombardy overpass on the inbound Gulf

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* A reproduction of the actual computer printout is shown in Appendix D-1.

Table 7

Typical Freeway and Exit Ramp Volumes
During "LANE BLOCKED" Display

Time	Freeway Volumes					Exit Ramp Volumes		
	Inside Lane	Middle Lane	Outside Lane	Total	Percent Change	Volume	Percent Change	% of Total Cross Section Output
1:04 - 1:11	154	186	166	506	--	32	--	5.9
1:12 - 1:19	164	177	164	505	-0.2	35	+8.6	6.5
1:20 - 1:27 Duration of Incident)	91	78	91	260	-48.5	124	+254.3	32.3
1:28 - 1:35	153	177	145	475	+82.7	36	-71.0	7.0
1:36 - 1:43	153	187	148	488	+2.7	27	-25.0	5.2

Freeway was analyzed.

This incident had a more severe impact on the freeway, both in duration and reduction in flow, than did the previous analysis incident. Initially, it could be proposed that a more severe incident (in terms of duration and flow) would be more conducive to diversion of on-freeway drivers. It was found, however, that in the absence of the illuminated sign, the drivers were apparently less certain about conditions ahead, and thus were less prone to divert.

The incident in question lasted at least 26 minutes. Therefore, two 26-minute intervals were analyzed. Table 8 shows the volumes and percentages of change in volumes during the 26-minute intervals before and after the occurrence of the incident.* The 62.4 percent reduction in flow on the freeway compared with the 48.5 percent reduction in the previous analysis (Table 7) indicates that freeway flow was reduced considerably. However, the Telephone exit ramp volume increased only 103.9 percent, as compared with the 254.3 percent increase during the incident in which "LANE BLOCKED" was displayed on the sign. Further, the exit ramp volumes accounted for only 18.4 percent of the total cross section output as compared with 32.3 percent in the previous analysis incident.

These figures suggest that the "LANE BLOCKED" display on the changeable message sign had a considerable effect on the tendency of the freeway motorists to divert. It appears that voluntary diversion accounted for only 40 to 50 percent of total diversion in the presence of "LANE BLOCKED" displays on the changeable message sign.

Another condition examined was effectiveness of the use of the freeway

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* A reproduction of the actual computer printout is shown in Appendix D-2.

Table 8

Typical Freeway and Exit Ramp Volumes

in the Absence of a "LANE BLOCKED" Display

Time	Freeway Volumes					Exit Ramp Volumes		
	Inside Lane	Middle Lane	Outside Lane	Total	Percent Change	Volume	Percent Change	% of Total Cross Section Output
3:29 - 3:54	719	769	973	2461	--	102	--	4.0
3:54 - 4:20 (Duration of Incident)	291	263	369	923	-62.4	208	+103.9	18.4

sign during maintenance operations. On April 15, 1975 at 10:14 a.m., the median lane of the freeway downstream of the freeway sign was closed for maintenance work on the median. (Maintenance signs and equipment were not visible from the sign location.) At that time, "LANE BLOCKED" was displayed on the sign. At 10:14, "KEEP RIGHT" was added, and was subsequently alternated with "1 (2) MI AHEAD."

Response to the message was substantial. Total freeway volumes dropped from 1935 for the 30-minute period prior to the lane blockage to 1679 for the next 30-minute interval, or 13.2 percent. However, left (median) lane volumes dropped 32.5 percent from 631 to 426. Middle and outside lanes showed volume changes of -6.9 percent and 0.0 percent, respectively. This substantial reduction in median lane volumes without corresponding volume changes in the other lanes indicates that motorists responded most favorably to the "KEEP RIGHT" message.

Several questions on the distributed questionnaire dealt with traffic operations. A summary of the responses to these operations-oriented questions are shown in Table 9. In all, 82 percent of the motorists who understood the sign used the information. Response to one question indicated that 47 percent of the motorists responding understood the signs and used the information. Only 12 percent of the respondents understood the signs and did not use the information. Seventy-eight percent of the remaining respondents (24% of the total) did not understand the signs and, subsequently, could not use the information. Therefore, it appears that getting the motorists to use the information is not nearly as formidable as providing information that the motorist understands.

When queried about specific responses to a "LANE BLOCKED" message, 44 percent indicated that they would "slow down and continue with caution."

Table 9

Summary of Responses to Operations-Oriented Questions

		Use Information				Desire Info Ahead			"Lane Blocked" Response						Left Freeway		Changed Lanes Bec. of Sign			Reaction to Hypothetical Sign			
Study	N	Understand and Use	Understand, Don't Use	Don't Understand	Blank	Yes	No	Blank	Slow Down and Continue	Used Alternate Route Due to Congestion	Used Alternate Route Due to Sign	Used Frontage Road Due to Sign	Used Frontage Road Due to Congestion	Blank	Because of Sign	Because of Congestion	Yes	No	Blank	Continue on Gulf Freeway	Take South Loop if Peak	Take South Loop if Convenient	Blank
A -- Total	138	85	16	30	7	125	10	3															
B -- Total	475	267	60	115	33	410	51	13															
C -- Total	139								61	9	9	2	0	58	39	97	81	51	7	53	17	42	13
Total	752	352	76	145	40	535	61	16	61	9	9	2	0	58	39	97	81	51	7	53	17	42	13
% of Total		57	12	24	7	87	10	3	44	7	7	1	0	41	28	70	58	37	5	38	12	31	9

Eleven percent responded that they would divert, 6 percent because of sign message, 5 percent because of evident congestion. Although this 6 percent seems small, it must be remembered that the intent of the signs is to divert some, not all, of the motorists. During the peak hour, this 6 percent would amount to more than 300 vehicles per hour.

It is important to point out here the reason for the apparent contradiction in the questionnaire results. Eighty-two percent of the respondents who understood the sign said they used the information, yet only six percent said they would divert. Although successful response to a changeable message sign system is typically measured in numbers of motorists diverted, there is apparently considerable intangible benefit to the motorist. This benefit may be simply that of reducing the driver's uncertainty about conditions ahead, but it seems that it is of significant importance to the motorists.

Twenty-eight percent of the respondents indicated that they had left the freeway, and 58 percent had changed lanes because of messages on the sign. In response to another question, 87 percent indicated a desire for information about conditions ahead.

As the South Loop provides another important alternative to the Gulf Freeway, motorists were asked to respond to a "LANE BLOCKED" message on a hypothetical sign on the inbound Gulf Freeway south of the Loop. If a "LANE BLOCKED" message were displayed on such a sign, 43 percent said they would use the Loop as an alternate, depending on time of day and convenience of the route.

In general, responses to the operations-oriented questions showed that the majority of the motorists desired the information and found it useful, but a smaller proportion actually used it to select an alternate route. Again, these responses seem realistic and to be expected given the quality

of alternate routes available inbound from the sign location.

Sign Design and Communications

Several questions were included in the questionnaires to determine whether the sign (and messages) actually communicated the intended meaning. Further, if the meaning was communicated, could it have been done better? Through the questionnaires, drivers indicated that which was useful, understood, and preferred. These results and other factors which affected the communications aspect of the signs will be discussed in this section.

Motorist observation of the sign and several specific messages was a necessary prerequisite for the analysis of responses to the communications questions. As shown in Table 10, 96 percent of the respondents had seen the freeway sign. From one-third to one-half of the motorists responding had seen one or more of three specific messages. The proportion of drivers having seen the various messages was very important in ascertaining percentage response.

A vast majority of the respondents indicated that all of the freeway condition messages were useful. Especially important was the 94 percent affirmative response to the usefulness of the "LANE BLOCKED" message. Nearly 200 of the respondents who indicated that the "LANE BLOCKED" message was useful had never seen it displayed, indicating that motorists in general feel a need for this information. The 83 and 90 percent affirmative response to the off-peak "OK" and "SLOW TRAFFIC" messages, respectively, confirms the hypothesis of the need for positive signing. In other words, the drivers want some indication of freeway conditions under almost all circumstances.

Motorist guidance messages received the greatest affirmative response. The traffic operations analysis presented earlier for the "KEEP RIGHT"

Table 10

Summary of Responses to Communications-Oriented Questions

		Noticed Sign			Had Seen Messages			Condition Messages Useful			Guidance Messages Useful		Preferred Other Messages					Overall Evaluation			
Study	N	Yes	No	No Answer	"Lane Blocked"	"Keep Left (Right)"	"Lane Blocked Use Frontage Road"	Off-Peak "OK"	Off-Peak "Slow Traffic"	"Lane Blocked"	"Keep Left (Right)"	"Use Frontage Road"	Off-Peak "OK"*	"Lane Blocked"	"Keep Left (Right)"	"Use Frontage Road"	No Answer	Very Useful	Useful, Could be Improved	Of Some Use	Of Very Little Use
A -- Total	138	129	7	2	56	47	34	116	125	128	130	129	16	25	20	18	109	42	68	13	8
B -- Total	475	463	8	4	241	207	171	393	427	444	449	442	58	155	144	143	333	123	243	69	29
C -- Total	139	130	9	0																	
Total	752	722	24	6	378	254	205	509	552	577	579	571	71	180	164	161	442	165	311	82	37
% of Total	--	96	3	1	50	41	33	83	90	94	94	93	12	29	27	26	72	27	51	13	6

* The alternative to off-peak "OK" was no message.

message was further confirmed by a 94 percent positive response to the usefulness of that message. The "USE FRONTAGE ROAD" message was also found useful by 93 percent of the respondents. This positive guidance greatly assists the driver by reducing his required decision-making load and permits him to devote more of his energies to other elements of the driving task.

Drivers were asked to indicate those messages which could be better stated. Although 16 to 25 percent indicated that they could think of better messages, the majority was satisfied with existing messages. Although most people could not improve on the messages, a slight majority, 51 percent, indicated, in an overall evaluation, that the system could be improved. Only six percent of the respondents found the system of very little use.

As part of the Questionnaire "B" studies, some comparison studies were conducted. The purpose of these comparison studies was to ascertain if there was any significant difference in response by motorists who were observed during "LANE BLOCKED" conditions, and motorists observed during "OK" conditions. In general, there was no significant difference in response between the two groups. The "LANE BLOCKED" group had about 8 percent (59.4% vs. 51.2%) more respondents indicate "I understood them (the signs) and use the information," and about 8 percent (28.6% vs. 21.2%) more respond that the signs are "Very useful, as they are." Other than this slightly more positive response from drivers experiencing adverse conditions, there were no significant differences.

One of the primary objectives of the study was to determine whether the motoring public would learn the freeway conditon-letter grade relationship without an educational program. Under the condition in which the study was performed, the public as a whole did not learn the relationship.

Responses to the letter grade questions (Table 11) showed that the motorists did not understand the rating scale. One of the major difficulties was that the scale was unanchored. Anchoring refers to the definition of the range of scale employed. As only one letter grade was displayed at a time, the motorist had no way of knowing whether the scale was 6 letters long or 26 letters long. Therefore, there was no way of knowing whether "FREEWAY CONDITION 'C'" was midway between free-flow and heavily congested (as was the case), or was very near free-flow (as would be the case in an A through Z scale). This problem could be alleviated in future installations by displays of the entire scale near the sign or in a public education program concerning sign operations.

However, other factors also contributed to the limited success of the rating scale. Respondents tended to associate the letter grades with the first letter of a word ("F" for Fair - 38%), instead of the intended rating scale. Since the time this project was implemented, other research has indicated that drivers may actually be able to distinguish only three levels of traffic flow: good ("OK"), normal (SLOW"), and poor ("LANE BLOCKED"). Use of six letter grades, then, required that two or more letter grades be applied to each discernable level of flow. Thus, it was not obvious to the driver that "A" meant "OK," "D" meant "SLOW TRAFFIC," and "X" meant "LANE BLOCKED." The practice of interspersing the other three letter grades among the discernable levels of flow, regardless of how technically accurate they were, may have significantly hampered the learning process.

The inconspicuousness of the letter grade within the sign, and the problem of bulb loss, may have contributed to the lack of letter grade-freeway condition association.

Table 11

Summary of Responses to Letter Grade Questions

	Freeway Condition				
Meaning Indicated	A_B *	C_A	F_B	X_A	X_B
Very Good	222	5	1	2	13
Good	101	9	1	2	8
Fair	5	42	179	1	6
Poor	1	17	43	11	33
Very Poor	1	5	47	33	140
A Lane is Blocked	1	1	1	10	16
I'm not sure	135	56	190	73	249
No Answer	9	3	13	6	10

*Subscripts refer to study in which letter-grade was included.

$N_A = 138$

$N_B = 475$

In general, the sign had a high target value as the vast majority of drivers had noticed it. A large portion of the drivers had seen the various messages displayed. Motorists queried found all of the messages useful, but a slight majority indicated that the system could be improved.

Comparison of Study Results

As the use of changeable message signs for motorist information is a relatively new concept, there are few standards which prescribe the characteristics required for successful operation. Therefore, to obtain a perspective, the results of this project were compared with an evaluation of a changeable message sign system in California. "User Acceptance Study of Freeway Motorists Advisory Systems" by Beers, et al., evaluated the operations of the changeable message sign system on the Santa Monica Freeway in Los Angeles (8). Although study techniques were somewhat different, selected comparisons of the effectiveness of the two systems can be obtained from parts of the results of both studies.

It should be noted at this point that the objectives of the two projects were radically different. While the intent of the Gulf Freeway project was to provide motorists with information to allow them to choose an appropriate action (i.e., take an alternate route, change lanes, etc.), the objectives of the Santa Monica Freeway project were to keep motorists on the freeway and in their lanes. In essence, the emphasis, in the Gulf Freeway project was on the improvement of traffic operations, while the emphasis in the Santa Monica Freeway project was safety. For this reason, then, the traffic operations evaluations of the two projects are not comparable. However, it is reasonable to compare the communications evaluations. Los Angeles motorists were asked to classify the usefulness of messages in

more detail -- "All," "Most," "Some," "Never." To be fair in this comparison, the Houston positive response must be compared with all but the "Never" response on the Los Angeles questionnaires. However, even with this allowance, only 83 percent of the LA respondents were non-negative to message usefulness. Whether this difference is due to the types of messages displayed, or due to motorists' general attitude in the two locales, or to some other factor is a matter of speculation. The fact remains, nevertheless, that the Houston motorists found the messages displayed more useful than did the Los Angeles motorists.

The other major area in which the results are comparable is that of overall evaluation. Reported results of the Los Angeles study showed a 47 percent positive reaction to the signs and 33 percent neutral reaction for a total of 80 percent non-negative reaction. Response to the overall evaluation by Houston motorists was broken down into four categories: "Very Useful," "Useful, Could Be Improved," "Of Some Use," "Of Very Little Use To Me." For comparison purposes, the latter category, a neutral response. The two remaining categories will constitute a positive response. On that basis, then, the Houston system received a 78 percent positive response and a 13 percent neutral response for a total non-negative response of 91 percent. Three percent of the respondents did not answer the evaluation question. Therefore, although the percentages shown indicate that 9 percent of the responses were not favorable, only 6 percent actually responded negatively, as opposed to 20 percent negative response rate in Los Angeles.

In general, the questionnaire comparisons indicate that the Houston project had greater public acceptance than did the Los Angeles project. This high degree of public acceptance should inspire considerable confidence

on the part of the State Department of Highways and Public Transportation in the further development of similar systems on the Gulf Freeway and other major freeways in the state.

Motorists' Comments

Several significant points were found in comments made by responding motorists. Some typical comments on the most frequently addressed subjects are presented here.

1. Usefulness of "Lane Blocked, so many miles ahead"

   Comment: *"Would be helpful to know which lane is blocked so you could avoid it."*

Motorists are seeking to determine which lane is blocked to allow them to take appropriate action. As the "KEEP RIGHT (LEFT)" messages and the "__ Miles Ahead" messages on the freeway sign were on the same line, it was not possible to display both simultaneously. These two lines could be accommodated without increasing the number of matrix inserts. The "FWY CONDITION" insert could be included as a painted message on the sign facia. It should not be eliminated, though, as the California study showed that a majority of the respondents felt that this was necessary to describe the purpose of the sign and to aid in the understanding of dynamic messages.

2. Usefulness of "Use Frontage Road"

   Comment: *"The frontage roads do not go straight through to town so it does not help me when I use them."*

This response points out the dependency of Texas motorists on frontage roads, especially adjacent to urban freeways. Drivers consider the frontage roads attractive alternatives to the congested freeway. The reopening of

the inbound frontage road at Lombardy will permit much greater flexibility in motorist diversion.

3. Sign location

Comment: *"My one complaint is the location. ...too close to town. I know several alternatives, but unless I am aware of trouble by Broadway it is of no use."*

This and similar comments received confirm a finding in the California report: drivers are not as willing to divert at relatively short distances from their destination. Although Telephone Road offers perhaps the best alternate route to downtown, it appears that drivers would prefer to divert to an alternate near the beginning of their trips. Consideration should be given in the future to accommodating this "all or nothing" attitude on the part of motorists.

4. Letter grades

Comment: *"Lettered messages are confusing because not everyone knows what letters apply to what sort of traffic."*

This topic has been discussed in detail. The comment is offered only as an indicator of the confusion experienced on the part of some of the motorists.

Not all of the comments received were negative. Following are some of the positive comments recieved.

"Any useful information helps."

"Idea is excellent, but improvement needed."

"The messages I have seen are very useful and I try to use them."

"I believe the traffic engineers are doing a fine job. ....."

One particular comment expressed an attitude that would be becoming to all drivers, especially freeway drivers:

"I never get in a hurry. I always have more time than lives."

Findings and Recommendations

The results of this study suggest that changeable message signs are an effective method of reducing urban freeway congestion. They can contribute to the reduction in overall delay to the motorist as well as the reduction in total demand on the freeway. Further, they effectively enhance safety by reducing traffic volumes and potential conflicts in the vicinity of incicents and lane closures. Especially important was the significantly positive reaction to the signs and toward the State Department of Highways and Public Transportation for their attempts at reducing congestion. The following specific findings and recommendations are drawn from the results of this research.

Findings

1. The Freeway sign was visible and had a high target value (96 percent of the 752 motorists responding to questionnaires had seen the signs).
2. Analyses showed that, during incident conditions, more motorists diverted from the freeway when the sign displayed "LANE BLOCKED" than when the signs were inoperative. Other analyses showed significant response to "KEEP RIGHT" messages.
3. Messages on the freeway sign (14-inch characters) were legible. Messages on the frontage road signs (6-inch characters) were not legible, probably due more to inadequate bulb brightness than to letter height. Letter spacing and formation on all signs were satisfactory.
4. Sign placement was satisfactory in the lateral direction, except that a few motorists indicated that the freeway sign (Sign A) was difficult to see from the inside (median) lane.

5. Sign locations were satisfactory within the geometric constraints that existed at the time of implementation. Closure of the inbound frontage road and opening of Loop 610E appreciably affected the desirability of sign location.
6. The freeway matrix sign performed quite satisfactorily for the intended purpose.
7. The motoring public did not satisfactorily learn the letter grade (A, B, C, D, F, X)-freeway condition relationship. The study was performed prior to any public education to determine whether the letter grades could be easily learned by driver association with current freeway conditions.
8. A majority of motorists said they understood the signs and that the messages were useful. Of the 519 who understood the signs 82 percent said they used the information.
9. The installation of a similar sign(s) on the inbound Gulf Freeway south of Loop 610 offers promising diversion potential as 43 percent indicated that they would be amenable to diversion at that location.
10. A vast majority of the respondents rated the system "useful" or "very useful." A slight majority indicated that the system could by improved by better choice of sign locations and improvements on messages.
11. The analysis of motorist comments indicated that it would be highly desirable to indicate which lane is blocked during "LANE BLOCKED" displays.
12. It was noted throughout the course of the project that one of the most tedious tasks in operating the signs was the necessity for continuous observation of traffic conditions via closed circuit television. Improvement of this facet of system operation would reduce response time and increase consistency of operation.

Recommendations

The results of this research should provide additional guidance in the formulation of plans and specifications of future matrix lamp changeable message sign systems. General freeway locations in major cities are suggested in the report where freeway traffic information could be useful. Following are some of the specific recommendations emanating from this study.

1. The State should consider the installation of one or more changeable message sign(s) on the inbound Gulf Freeway south of Loop 610 in Houston. As there has been considerable change in the geometrics of the Gulf Freeway corridor since the 1971 systems analysis study, another such study should be undertaken to ascertain the effects of the new alternate routes, and to update the 1971 study to reflect these effects.
2. Consideration should be given to the inclusion of changeable message signs as part of the Urban Freeway Traffic Management Center concept. A possible application of these signs could be on the inbound approaches of radial freeways at their interchanges with loop freeways where the route diversion potentials are high.
3. Consideration should be given to the study of similar systems for use on freeways or major highways with no or limited outlets such as through elevated sections and causeways. Such systems could be used for informing/warning motorists of conditions on the facility to permit them to respond properly and safely to incidents or lane closures.
4. It appears extremely desirable that future changeable message signs be automated. An automated system would relieve control center personnel of the extremely tedious task of continuously watching the closed circuit television monitors. Automated systems could be integrated with

existing surveillance and control systems. Consideration should be given to the development and evaluation of reliable operational strategies containing a suitable changeable message sign algorithm.

Acknowledgments

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The authors also wish to acknowledge Messrs. W. R. McCasland and G. P. Ritch of the Texas Transportation Institute for their assistance throughout the project, Dr. R. D. Huchingson of TTI for his assistance in the development of the questionnaires, and Mr. Richard Fullerton of TTI for his coordination of questionnaire studies and data collection.

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APPENDICES

APPENDIX A

SIGN SPECIFICATIONS

TEXAS HIGHWAY DEPARTMENT
SPECIAL SPECIFICATION
CHANGEABLE MESSAGE SIGN SYSTEM
(MATRIX TYPE)

General

The Contractor shall fabricate and deliver a-Changeable Message Sign System. As part of the system, the Contractor shall furnish the matrix inserts for the three signs (designated Sign A, B, and C) illustrated in Figure 1. The inserts are to be installed by the State in the open location of the signs.

The Contractor shall also design, furnish, and assemble hardware for each sign location which includes: 1) local overriding maintained contact manual switches in an electric control box and 2) terminal points for the connection of a remote control device. The sign supports and plywood facias will be furnished and installed by the State.

Twenty days after the contract is awarded, the Contractor shall submit to the Engineer for approval six sets of mechanical drawings, electrical drawings, and bills of material describing the system. These drawings shall also show recommended mounting arrangements between the matrix inserts and plywood facias.

A complete maintenance and operational manual of the sign system shall be submitted to the Engineer with shipment of the system. The manual shall include maintenance procedures, electrical schematic diagrams, and bills of material.

Quality

The design, workmanship, and material shall be of the highest quality in order to maintain the continued integrity of the system.

Testing and Maintenance

Prior to acceptance, the system shall undergo a two-week shop test period. This test will be used to guarantee that the minimum specifications have been met or exceeded. It is intended that the two-week test period will be accomplished within 30 days after receipt of all material.

After acceptance, the Contractor shall guarantee all parts and material for a one-year period and shall supply the State with any replacement of parts or materials that become defective during this one year period with the exception of the lamps.

Matrix Sign Inserts

The modular inserts shall be lamp matrix type and designed to clearly illuminate a single traffic message when energized. The size of the letters for each message shall be as indicated in Figure 1 and Table 1.

The upper left matrix insert for each sign shall be capable of displaying the message "FWY CONDITION" and shall only contain sufficient lamps to display this message.

The upper right matrix insert shall be a single module insert and shall be capable of displaying the following messages: A, B, C, D, F, and X. This insert shall contain sufficient lamps to provide the flexibility of changing any one of the above six messages to display any one of the twenty-six alphabetic characters in the event that the State wishes to alter the list of messages at a later date. The system shall be so designed that any one of the above six alphabetic characters can be changed to display any one of the twenty-six alphabetic characters merely by changing an electronic printed circuit board.

The middle and bottom inserts shall have the capability of displaying the messages listed in Table 1. These inserts shall contain sufficient lamps to provide the flexibility of displaying all possible combinations of words and numbers in the event that the State desires to alter the list of required messages at a later date. The system shall be designed so that any one of the messages listed in Table 1 could be changed to display another message merely by changing electronic printed circuit boards. The system shall be so designed that two additional messages can be added to both the middle and bottom inserts at a later date.

The system shall be designed such that when power is turned on to the sign location only the message "FWY CONDITION" shall be displayed.

The lamps for the 12" matrix inserts shall be capable of providing a minimum of 10,000 hours service. The lamps for the 6" matrix inserts shall be capable of providing a minimum of 3,600 hours service. Lamps shall all be brass base and miniature bayonet.

The sign shall be designed such that the lamp sockets or lamp socket brackets shall resist corrosion.

The inserts shall be complete with brackets to mount to 3/4" or 5/8" plywood facias, and shall include switches, bulbs, ballast, heaters, thermostats, etc., where needed to make operative inserts.

The system shall be designed so as to yield a minimum of 60 feet of legibility distance per inch of letter height under sunlight conditions.

Housing

The entire housing shall be constructed of highgrade aluminum in a thickness necessary to provide a completely rigid frame. The fabricating procedure shall be in accordance with Military Specification 5541.

Suitable baffle plates shall be used in the construction of the sign to provide for proper mounting of the lamp sockets and to prevent any observer from seeing the spread of light between lamps. In addition, a suitable sun shade shall be mounted external of the lamps so as to prevent sun phantom.

Suitable reinforcing shall be provided along all front edges allowing for installation to a 3/4" or 5/8" plywood sign panel. Maintenance of lamps and electrical equipment shall be from the front of the sign.

The sign control logic assembly, the power distribution assembly, and the manual field control assembly for each sign shall be enclosed in a weather-type aluminum sign control cabinet to be located near ground level at the sign location. The interconnecting cable between the sign and the sign control cabinet will be furnished and installed by the State. Terminals for the interconnecting cable(s) are to be supplied by the Contractor and shall be clearly marked as to function. Three sign control cabinets shall be required.

Electrical System

The Contractor shall ensure that the sign control circuit is compatible with the user supplied remote control and monitor unit. The user supplied remote control and monitor circuit shall require one relay contact for the control of each message on each matrix insert, and one relay coil for the monitoring of each message on each matrix insert. The Contractor shall provide terminal connections in each sign control cabinet to interconnect to the remote control unit and monitoring unit furnished and installed by others. The relays shall be 12 volt DC type Brumfield #KHU 17D12-12 or plug-in type equivalent. Total coil current shall be 100 ma or less. The coil leads shall be brought to the terminals isolated from gound or system voltages. It is intended that these relays be supplied by the Contractor, and it is further intended that by closure of these relays, either remotely or by actuation of the local switches, will activate a message. The terminal strip connections including those for future remote controls shall be clearly identified and the connecting wires marked for ease in trouble shooting.

Provisions shall be made for each sign so that the messages on each insert having variable messages can be controlled independently.

The local manual switches for the control of messages shall be clearly labeled with respect to insert and message.

The system shall be designed for satisfactory performance for outside ambient temperatures ranging between -10° F. and +110° F.

A step-down transformer or similar device shall be provided to illuminate the incandescent lamps making up the messages on a multi-stage basis. The multi-stage transformer or similar dimming device shall be automatically switched from daytime to nighttime operation by use of a photoelectric device furnished by the Contractor. This dimming device shall be located in each sign control cabinet. The purpose is to provide the proper intensities or light levels during daytime and nighttime conditions.

All wiring within the sign cabinets including that in the control cabinets shall be in accordance with the requirements of the National Electric Code. All terminal boards shall be enclosed in suitable boxes to prevent accidental shock or shorts by servicing personnel. All necessary grounding and circuit breakers shall be in accordance with the National Electric Code. All wire shall be stranded copper rated at a minimum of 300 volts and 105° Centigrade.

All electrical connections shall be, inasmuch as practical, of modular design, that is: plug-in connections to minimize wiring disconnection and reconnection during normal servicing and/or replacement of critical components. All relays shall be plug-in type.

Spare Parts

The Contractor shall furnish with the sign system, fifty (50) each of the various types of lamps used.

Painting

The entire sign inside and outside shall be painted dull black. The first coat is to be zinc chromate primer followed by two coats of the finished color. All surfaces shall be painted.

Delivery

Shipment shall be required within ninety (90) days after the Contractor is notified by the Engineer of approval of the drawings. The Contractor will be responsible for all shipping charges. Delivery shall be made to 1702 FM 1959, Houston, Texas, from 8:00 a.m. to 5:00 p.m., Monday through Friday.

Measurement

Changeable message sign system shall be measured as a complete matrix insert

system for three signs complete with all necessary equipment including mounting hardware, lamps, switches, ballast, heater thermostats, relay cabinets, message inserts, circuit boards, terminal strips, sun shield as described by this specification to form three complete changeable message signs without plywood facias.

Payment

Changeable message sign system shall be payed for at the full price bid which price shall include payment for all material furnished and assembled necessary for three complete changeable message signs without plywood facias.

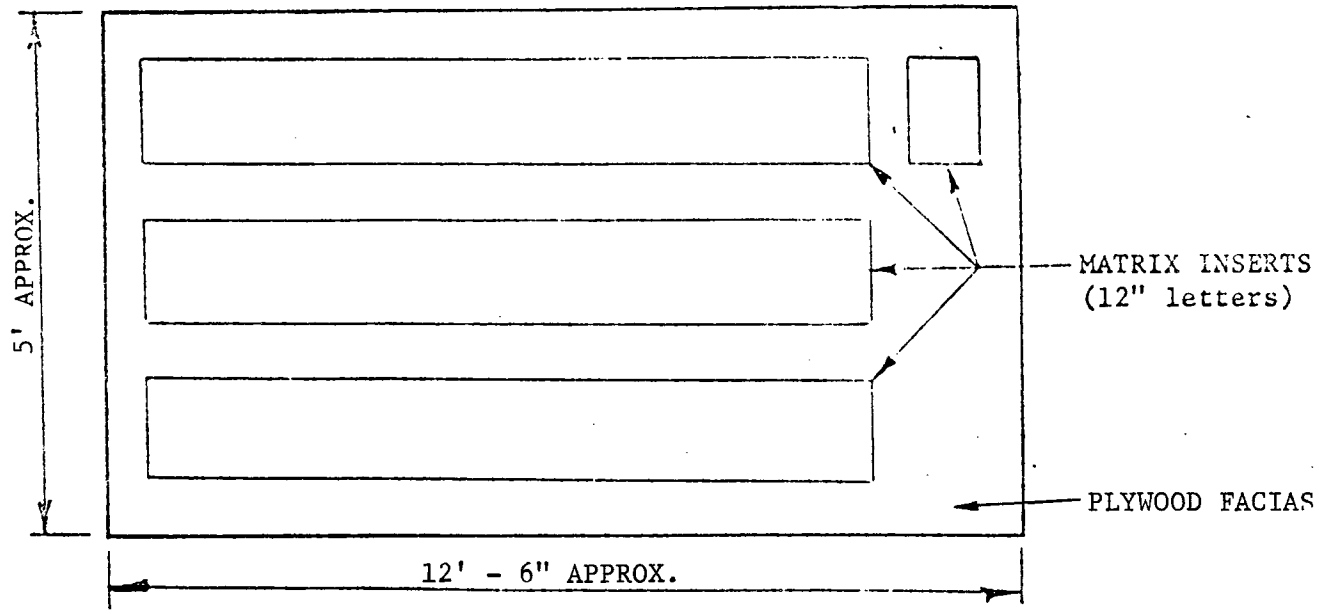
Table 1

MESSAGE DISPLAYS FOR MATRIX INSERTS*

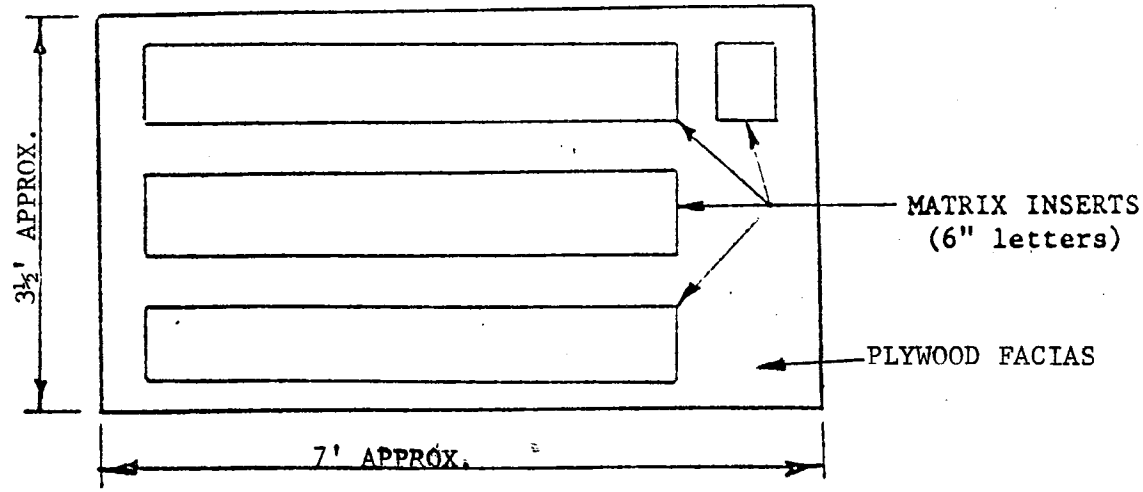
Sign A (12" inserts)		Sign B (6" inserts)		Sign C (6" inserts)	
Middle Insert	Lower Insert	Middle Insert	Lower Insert	Middle Insert	Lower Insert
OK	3 MI AHEAD	OK	3 MI AHEAD	OK	3 MI AHEAD
SLOW TRAFFIC	2 MI AHEAD	SLOW TRAFFIC	2 MI AHEAD	SLOW TRAFFIC	2 MI AHEAD
LANE BLOCKED	1 MI AHEAD	LANE BLOCKED	1 MI AHEAD	LANE BLOCKED	1 MI AHEAD
KEEP LEFT	KEEP RIGHT	USE	FRONTAGE RD	RAMP CLOSED	USE NEXT RAMP

*The Upper Left Insert for Signs A, B, and C shall contain the message "FWY CONDITION."

The Upper Right Module Insert for Signs A, B, and C shall be capable of displaying the following messages: A, B, C, D, F, and X.



Sign A



Signs B and C

Figure 1 - MATRIX TYPE CHANGEABLE MESSAGE SIGNS

APPENDIX B

LETTER, QUESTIONNAIRES, AND RESPONSE SUMMARIES

APPENDIX B-1

LETTER, QUESTIONNAIRE "A," AND RESPONSE SUMMARY

TEXAS HIGHWAY DEPARTMENT SIGN QUESTIONNAIRE

1. *How often do you travel the Gulf Freeway each week?*

   1-2 times_____ 3-5 times_____ 5-10 times_____ 10 or more_____

2. *Have you ever noticed the electronic signs near Wayside or Telephone Road which stated a lane was blocked so many miles ahead or that traffic was "slow" or was "OK?"*

   Yes_____ No_____

3. *When the sign does not display any message, what does it mean to you?*

   Traffic is light and normal_____; The equipment has failed_____;
   The surveillance office is closed_____; I'm not sure_____.

4. *During off-peak periods, the sign usually displays the word "OK," meaning traffic flow ahead is normal. Do you feel that this message is useful?*

   Yes_____ No_____

   Would you prefer instead that no message be displayed?

   Yes_____ No_____

5. *During off-peak periods, the sign sometimes states "Slow Traffic, so many miles ahead" telling you how far ahead to expect congestion. Do you feel that this message is useful?*

   Yes_____ No_____

6. *The sign displays "Lane Blocked, so many miles ahead" when there has been an incident or accident further ahead. Do you feel this message is useful?*

   Yes_____ No_____

7. *When the lane blockage is only 1 mile ahead, the sign occasionally tells you to "Keep Left" or "Keep Right" as necessary to avoid the blocked lane. Do you feel this message is useful?*

   Yes_____ No_____

8. *Another possibility when a lane is blocked and you are not yet on the freeway is a message which tells you to "use the frontage road" and thus avoid the congestion. Do you feel this message is useful?*

   Yes_____ No_____

9. *Have you seen the messages in questions 6, 7, and 8 displayed?*

   a. Lane Blocked_____; b. Keep Left (Right)_____; c. Use Frontage Road_____.

   Can you think of better messages for the above?

   a. _____; b. _____; c. _____.

10. *Sometimes the sign displays a message that reads "FREEWAY CONDITION C." In your opinion this means that the freeway traffic condition ahead is?*

    Very good_____; Good_____; Fair_____; Poor_____; Very poor_____; A lane is blocked_____; I'm not sure_____.

11. *A message "FREEWAY CONDITION X" means that the freeway traffic condition ahead is:*

Very good_____; Good_____; Fair_____; Poor_____; Very poor_____; A lane is blocked_____; I'm not sure_____.

12. *During rush hour traffic, the flow of traffic on the Gulf Freeway is frequently slow, sometimes bumper-to-bumper. The condition of traffic ahead may also be slow. Under these conditions, which of the following messages would you feel is most meaningful to you to describe this situation?*

"Slow traffic, so many miles ahead"_____; No message displayed_____; A letter grade indicating the level of congestion "so many miles ahead"_____; Slow traffic, so many miles ahead" along with a letter grade_____.

13. *It is possible to determine and display on the sign the number of miles ahead the traffic condition will improve to a normal driving speed. Would you be interested in having this information displayed while you are traveling in slow traffic?*

Yes_____ No_____

14. *Which of the following messages would you prefer to tell you that traffic was improved ahead?*

"OK, so many miles ahead"_____; "Degree of congestion indicated by a letter grade and so many miles ahead"_____; No message at all_____.

15. *In your driving experiences on the Gulf Freeway, which of the following statements would best describe your reactions to the signs?*

a. I understand them and use the information_____; b. I understand them, but do not use the information much_____; c. I do not understand some of the messages and so am not able to use them_____.

*If c., specify which messages are not understood:*_____

_____

_____

16. *In general, my overall evaluation of the signs is as follows:*

Very useful, as they are_____; Useful, but could be improved_____; Of some use_____; Of very little use to me_____.

17. *Age:*

Under 25_____; 25-44_____; 45 or older_____.

18. *Education completed:*

Grade school_____; High school_____; Business college or trade school_____; Two years of college_____; Senior college_____; Graduate or professional school_____.

.....

Thank you, sincerely. Please return this form to the Texas Highway Department using the enclosed envelope.

SUMMARY OF RESPONSES TO QUESTIONNAIRE "B"

1. How often do you travel the Gulf Freeway each week?

No Answer	2	1 %
1 - 2 Times	44	32 %
3 - 5 Times	24	17 %
5 - 10 Times	27	20 %
10 or More	41	30 %

2. Have you ever noticed the electronic signs near Wayside or Telephone Road which stated a lane was blocked so many miles ahead or that traffic was "slow" or was "OK"?

No Answer	2	1 %
Yes	129	94 %
No	7	5 %

3. When the sign does not display any message, what does it mean to you?

No Answer	3	2 %
Traffic is light and normal	75	54 %
The equipment has failed	15	11 %
The surveillance office is closed	19	14 %
I'm not sure	26	19 %

4. During off-peak periods, the sign usually displays the work "OK" meaning traffic flow ahead is normal. Do you feel that this message is useful?

No Answer	1	1 %
Yes	116	84 %
No	21	15 %

Would you prefer instead that no message be displayed?

No Answer	8	6 %
Yes	16	11 %
No	114	83 %

5. During off-peak periods, the sign sometimes states "Slow Traffic, so many miles ahead" telling you how far ahead to expect congestion. Do you feel that this message is useful?

No Answer	4	3 %
Yes	125	91 %
No	9	6 %

6. The sign displays "Lane Blocked, so many miles ahead" when there has been an incident or accident further ahead. Do you feel this message is useful?

No Answer	3	2 %
Yes	128	93 %
No	7	5 %

7. When the lane blockage is only 1 mile ahead, the sign occasionally tells you to "Keep Left" or "Keep Right" as necessary to avoid the blocked lane. Do you feel this message is useful?

No Answer	3	2 %
Yes	130	94 %
No	5	4 %

8. Another possibility when a lane is blocked and you are not yet on the freeway is a message which tells you to "Use the frontage road" and thus avoid the congestion. Do you feel this message is useful?

No Answer	14	3 %
Yes	129	93 %
No	5	4 %

9. Have you ever seen the message in 6, 7, and 8 displayed?

No Answer	49	36 %
Lane Blocked	23	17 %
Keep left (right)	14	10 %
Use frontage road	3	2 %
Lane blocked & keep left (right)	14	10 %
Lane blocked & use frontage road	1	1 %
Keep left (right) & use frontage road	1	1 %
All three	33	24 %

Can you think of better messages for the above?

No Answer	109	79 %
Lane blocked	7	5 %
Keep left (right)	2	1 %
Use frontage road	0	0 %
Lane blocked & keep left (right)	1	1 %
Lane blocked & use frontage road	1	1 %
Keep left (right) & use frontage road	0	0 %
All three	18	13 %

10. Sometimes the sign displays a message that reads "Freeway condition C". In your opinion this means that freeway traffic condition ahead is:

No Answer	3	2 %
Very good	5	4 %
Good	9	7 %
Fair	42	30 %
Poor	17	12 %
Very poor	5	4 %
A lane is blocked	1	1 %
I'm not sure	56	40 %

Would you prefer instead that no message be displayed?

No Answer	8	6 %
Yes	16	11 %
No	114	83 %

5. During off-peak periods, the sign sometimes states "Slow Traffic, so many miles ahead" telling you how far ahead to expect congestion. Do you feel that this message is useful?

No Answer	4	3 %
Yes	125	91 %
No	9	6 %

6. The sign displays "Lane Blocked, so many miles ahead" when there has been an incident or accident further ahead. Do you feel this message is useful?

No Answer	3	2 %
Yes	128	93 %
No	7	5 %

7. When the lane blockage is only 1 mile ahead, the sign occasionally tells you to "Keep Left" or "Keep Right" as necessary to avoid the blocked lane. Do you feel this message is useful?

No Answer	3	2 %
Yes	130	94 %
No	5	4 %

8. Another possibility when a lane is blocked and you are not yet on the freeway is a message which tells you to "Use the frontage road" and thus avoid the congestion. Do you feel this message is useful?

No Answer	14	3 %
Yes	129	93 %
No	5	4 %

9. Have you ever seen the message in 6, 7, and 8 displayed?

No Answer	49	36 %
Lane Blocked	23	17 %
Keep left (right)	14	10 %
Use frontage road	3	2 %
Lane blocked & keep left (right)	14	10 %
Lane blocked & use frontage road	1	1 %
Keep left (right) & use frontage road	1	1 %
All three	33	24 %

Can you think of better messages for the above?

No Answer	109	79 %
Lane blocked	7	5 %
Keep left (right)	2	1 %
Use frontage road	0	0 %
Lane blocked & keep left (right)	1	1 %
Lane blocked & use frontage road	1	1 %
Keep left (right) & use frontage road	0	0 %
All three	18	13 %

10. Sometimes the sign displays a message that reads "Freeway condition C". In your opinion this means that freeway traffic condition ahead is:

No Answer	3	2 %
Very good	5	4 %
Good	9	7 %
Fair	42	30 %
Poor	17	12 %
Very poor	5	4 %
A lane is blocked	1	1 %
I'm not sure	56	40 %

11. A message "Freeway condition X" means that the freeway traffic condition ahead is:

No Answer	6	4 %
Very good	2	1 %
Good	2	1 %
Fair	1	1 %
Poor	11	8 %
Very poor	33	24 %
A lane is blocked	10	8 %
I'm not sure	73	53 %

12. During rush hour traffic, the flow of traffic on the Gulf Freeway is frequently slow, sometimes bumper to bumper. The condition of traffic ahead may also be slow. Under these conditions, which of the following messages would you feel is most meaningful to you to describe this situation?

No Answer	6	4 %
"Slow traffic, so many miles ahead"	74	54 %
No message displayed	7	5 %
A letter grade indicating the level of congestion "so many miles ahead"	2	1 %
"Slow traffic, so many miles ahead" along with a letter grade	49	36 %

13. It is possible to determine and display on the sign the number of miles ahead the traffic condition will improve to a normal driving speed. Would you be interested in having this information displayed while you are traveling in slow traffic?

No Answer	3	2 %
Yes	125	91 %
No	10	7 %

14. Which of the following messages would you prefer to tell you that traffic was improved ahead?

No Answer	3	2 %
"OK, so many miles ahead"	113	82 %
"Degree of congestion indicated by a letter grade and so many miles ahead"	18	13 %
No message at all	4	3 %

15. In your experiences on the Gulf Freeway, which of the following statements would best describe your reactions to the signs?

No Answer	7	5 %
I understand them and use the information	85	62 %
I understand them, but do not use the information much	16	11 %
I do not understand some of the messages and so am not able to use them	30	22 %

16. In general, my overall evaluation of the signs are as follows:

No Answer	7	5 %
Very useful, as they are	42	31 %
Useful, but could be improved	68	49 %
Of some use	13	9 %
Of very little use to me	8	6 %

17. Age:

No Answer	2	1 %
Under 25	20	15 %
25 - 44	52	38 %
45 or older	64	46 %

18. Education completed:

No Answer	3	2 %
Grade school	7	5 %
High school	47	34 %
Business college or trade school	6	4 %
Two years of college	19	14 %
Senior college	29	21 %
Graduate or professional school	27	20 %

APPENDIX B-2

QUESTIONNAIRE "B" AND RESPONSE SUMMARY

TEXAS HIGHWAY DEPARTMENT SIGN QUESTIONNAIRE - II

1. *How often do you travel the Gulf Freeway each week?*

   1-2 times_____ 3-5 times_____ 5-10 times_____ 10 or more_____

2. *Have you ever noticed the electronic signs near Wayside or Telephone Road which stated a lane was blocked so many miles ahead or that traffic was "slow" or was "OK"?*

   Yes_____ No_____

3. *When the sign does not display any message, what does it mean to you?*

   Traffic is light and normal_____; The equipment has failed_____;
   The surveillance office is closed_____; I'm not sure_____.

4. *During off-peak periods, the sign usually displays the word, "OK" meaning traffic flow ahead is normal. Do you feel that this message is useful?*

   Yes_____ No_____

   Would you prefer instead that no message be displayed?

   Yes_____ No_____

5. *During off-peak periods, the sign sometimes states "Slow Traffic, so many miles ahead" telling you how far ahead to expect congestion. Do you feel that this message is useful?*

   Yes_____ No_____

6. *The sign displays "Lane Blocked, so many miles ahead" when there has been an incident or accident further ahead. Do you feel this message is useful?*

   Yes_____ No_____

7. *When the lane blockage is only 1 mile ahead, the sign occasionally tells you to "Keep Left" or "Keep Right" as necessary to avoid the blocked lane. Do you feel this message is useful?*

   Yes_____ No_____

8. *Another possibility when a lane is blocked and you are not yet on the freeway is a message which tells you to "use the frontage road" and thus avoid the congestion. Do you feel this message is useful?*

   Yes_____ No_____

9. *Have you seen the messages in Questions 6, 7, and 8 displayed?*

   a. Lane Blocked_____; b. Keep Left (Right)_____; c. Use Frontage Road_____.

   Can you think of better messages for the above?

   a. _____; b. _____ c. _____.

10. *Sometimes the sign displays a message that reads "FREEWAY CONDITION X." In your opinion this means that the freeway traffic condition ahead is:*

    Very good_____ Good_____; Fair_____; Poor_____; Very poor_____;

    A lane is blocked_____; I'm not sure_____.

11. *A message "FREEWAY CONDITION A" means that the freeway traffic condition ahead is:*

Very good_____; Good_____; Fair_____; Poor_____; Very Poor_____;

A lane is blocked_____; I'm not sure_____.

12. *During rush hour traffic, the flow of traffic on the Gulf Freeway is frequently slow, sometimes bumper-to-bumper. The condition of traffic ahead may also be slow. Under these conditions, which of the following messages would you feel is most meaningful to you to describe this situation?*

"Slow traffic, so many miles ahead"_____; No message displayed_____;
A letter grade indicating the level of congestion "so many miles ahead"_____;
"Slow traffic, so many miles ahead" along with a letter grade_____.

13. *It is possible to determine and display on the sign the number of miles ahead the traffic condition will improve to a normal driving speed. Would you be interested in having this information displayed while you are traveling in slow traffic?*

Yes_____ No_____

14. *Which of the following messages tells you best that your current traffic situation will get better further on down the freeway?*

"OK, so many miles ahead"_____; "Degree of congestion indicated by a letter grade and so many miles ahead"_____; No message at all_____.

15. *In your driving experiences on the Gulf Freeway, which of the following statements would best describe your reactions to the signs?*

a. I understand them and use the information_____; b. I understand them, but do not use the information much_____; c. I do not understand some of the messages and so am not able to use them_____.

*If c., specify which messages are not understood:*_____

_____

_____

16. *In general, my overall evaluation of the signs are as follows:*

Very useful, as they are_____; Useful, but could be improved_____;
Of some use_____; Of very little use to me_____.

17. *Age:*

Under 25_____; 25-44_____; 45 or older_____.

18. *A message "FREEWAY CONDITION F" means that the freeway traffic condition ahead is:*

Very good_____; Good_____; Fair_____; Poor_____; Very poor_____;

A lane is blocked_____; I'm not sure_____.

.....

Thank you, sincerely. Please return this form to the Texas Highway Department using the enclosed envelope.

SUMMARY OF RESPONSES TO QUESTIONNAIRE "B"

1. How often do you travel the Gulf Freeway each week?

No Answer	8	1.7 %
1 - 2 Times	73	15.4 %
3 - 5 Times	67	14.1 %
5 - 10 Times	159	33.5 %
10 or More	168	35.3 %

2. Have you ever noticed the electronic signs near Wayside or Telephone Road which stated a lane was blocked so many miles ahead or that traffic was "slow" or was "OK"?

No Answer	4	0.8 %
Yes	463	97.5 %
No	8	1.7 %

3. When the sign does not display any message, what does it mean to you?

No Answer	4	0.8 %
Traffic is light and normal	245	51.5 %
The surveillance office is closed	55	11.6 %
The equipment has failed	54	11.5 %
I'm not sure	117	24.6 %

4. During off-peak periods, the sign usually displays the word, "OK" meaning traffic flow ahead is normal. Do you feel that this message is useful?

No Answer	3	0.6 %
Yes	398	83.8 %
No	74	15.6 %

Would you prefer instead that no message be displayed?

No Answer	25	5.3 %
Yes	58	12.2 %
No	392	82.5 %

5. During off-peak periods, the sign sometimes states "Slow Traffic, so many miles ahead" telling you how far ahead to expect congestion. Do you feel that this message is sueful?

No Answer	8	1.7 %
Yes	427	89.9 %
No	40	8.4 %

6. The sign displays "Lane Blocked, so many miles ahead" when there has been an incident or accident further ahead. Do you feel this message is useful?

No Answer	9	1.9 %
Yes	449	94.5 %
No	17	3.6 %

7. When the lane blockage is only 1 mile ahead, the sign occasionally tells you to "Keep Left" or "Keep Right" as necessary to avoid the blocked lane. Do you feel this message is useful?

No Answer	12	2.5 %
Yes	449	94.5 %
No	14	3.0 %

8. Another possibility when a lane is blocked and you are not yet on the freeway is a message which tells you to "use the frontage road" and thus avoid the congestion. Do you feel this message is useful?

No Answer	13	2.7 %
Yes	442	93.1 %
No	20	4.2 %

9. Have you seen the messages in Questions 6, 7, and 8 displayed?

No Answer	119	25.0 %
Lane Blocked	73	15.4 %
Keep Left (Right)	39	8.2 %
Use Frontage Road	7	1.5 %
Lane blocked & keep left (right)	62	13.1 %
Lane blocked & use frontage road	3	0.6 %
Keep left (right) & use frontage road	4	0.8 %
All three	168	35.4 %

Can you think of better messages for the above?

No Answer	316	66.6 %
Lane blocked	13	2.7 %
Keep left (right)	2	0.4 %
Use frontage road	1	0.2 %
Lane blocked & keep left (right)	0	0.0 %
Lane blocked & use frontage road	1	0.2 %
Keep left (right) & use frontage road	0	0.0 %
All three	142	29.9 %

10. Sometimes the sign displays a message that reads "FREEWAY CONDITION X". In your opinion this means that the freeway traffic condition ahead is:

No Answer	10	2.1 %
Very good	13	2.7 %
Good	8	1.7 %
Fair	6	1.3 %
Poor	33	6.9 %
Very Poor	140	29.5 %
A lane is blocked	16	3.4 %
I'm not sure	249	52.4 %

11. A message "FREEWAY CONDITION A" means that the freeway traffic condition ahead is:

No Answer	9	1.9 %
Very good	222	46.7 %
Good	101	21.3 %
Fair	5	1.1 %
Poor	1	0.2 %
Very poor	1	0.2 %
A lane is blocked	1	0.2 %
I'm not sure	135	28.4 %

12. During rush hour traffic, the flow of traffic on the Gulf Freeway is frequently slow, sometimes bumper-to-bumper. The condition of traffic ahead may also be slow. Under these conditions, which of the following messages would you feel is most meaningful to you to describe this situation?

No Answer	19	4.0 %
Slow traffic, so many miles ahead	224	47.2 %
No message displayed	24	5.1 %
A letter grade indicating the level of congestion "so many miles ahead"	50	10.5 %
"Slow traffic, so many miles ahead" along with a letter grade	158	33.2 %

13. It is possible to determine and display on the sign the number of miles ahead the traffic condition will improve to a normal driving speed. Would you be interested in having this information displayed while you are traveling in slow traffic?

No Answer	13	2.8 %
Yes	410	86.4 %
No	51	10.8 %

14. Which of the following messages tells you best that your current traffic situation will get better further on down the freeway?

No Answer	10	2.2 %
OK, so many miles ahead	357	75.4 %
Degree of congestion indicated by a letter grade and so many miles ahead	88	18.7 %
No message at all	17	3.7 %

15. In your driving experiences on the Gulf Freeway, which of the following statements would best describe your reactions to the signs?

No Answer	33	6.9 %
I understand them and use the information	267	56.2 %
I understand them, but do not use the information much	60	12.7 %
I do not understand some of the messages and so am not able to use them	115	24.2 %

16. In general, my overall evaluation of the signs are as follows:

No Answer	11	2.3 %
Very useful, as they are	123	25.9 %
Useful, but could be improved	243	51.2 %
Of some use	69	14.5 %
Of very little use to me	29	6.1 %

17. Age:

No Answer	7	1.5 %
Under 25	99	20.8 %
25 - 44	191	40.2 %
45 or Older	178	37.5 %

18. A message "FREEWAY CONDITION F" means that the freeway traffic condition ahead is:

No Answer	13	2.7 %
Very good	1	0.2 %
Good	1	0.2 %
Fair	179	37.7 %
Poor	43	9.1 %
Very poor	47	9.0 %
A lane is blocked	1	0.2 %
I'm not sure	190	40.0 %

APPENDIX B-3

QUESTIONNAIRE "C" AND RESPONSE SUMMARY

TEXAS HIGHWAY DEPARTMENT SIGN QUESTIONNAIRE - III

1. *How often do you travel the Gulf Freeway each week?*

   1-2 times_____ 3-5 times_____ 5-10 times_____ 10 or more_____

2. *Have you ever noticed the electronic sign near Wayside or Telephone Road which stated a lane was blocked so many miles ahead or that traffic was "slow" or was "OK"?*

   Yes_____ No_____

3. *The sign sometimes displays "Lane Blocked, so many miles ahead" telling you when there has been an accident or incident further ahead toward downtown. Have you seen this message?*

   Yes_____ No_____

4. *If your answer to Question 3 was "Yes", please answer this question. When the "Lane Blocked" message was displayed, which of the following did you do?*

   I slowed down and continued with caution_____
   I left the freeway and took another route because of the congestion_____
   I left the freeway and took another route because of the sign message_____
   I left the freeway and used the frontage road because of the congestion_____
   I left the freeway and used the frontage road because of the sign message_____

5. *Have you ever left the freeway and used the frontage road or alternate route because of any message displayed by the electronic sign?*

   Yes_____ No_____

6. *Have you ever left the freeway and used the frontage road or alternate route to bypass congestion?*

   Yes_____ No_____

7. *Sometimes the sign suggests that you should "Keep Right" or "Keep Left". Have you ever made a lane change from one lane to the next because of these messages being displayed?*

   Yes_____ No_____

8. *Suppose the electronic sign were moved to south of the South Loop (I-610) interchange. The sign would be located inbound on the Gulf Freeway. If the sign said "Gulf Freeway Lane Blocked 2 Miles Ahead", what would you do?*

I would probably continue driving on the Gulf Freeway because I have no other good route to my destination_____
I would take the South Loop to work if this were the rush hours_____
I would take the South Loop to my destination if it were convenient_____
I doubt the sign is accurate and would not pay any attention to it_____
I don't know what I would do_____

9. *Age:*

Under 25_____ 25-44_____ 45 or older_____

. . . . . .

Thank you, sincerely. Please return this form to the Texas Highway Department using the enclosed envelope.

SUMMARY OF RESPONSES TO QUESTIONNAIRE "C"

1. How often do you travel the Gulf Freeway each week?

No Answer	7	5 %
1 - 2 Times	26	19 %
3 - 5 Times	20	14 %
5 - 10 Times	32	23 %
10 or More	53	38 %

2. Have you ever noticed the electronic sign near Wayside or Telephone Road which stated a lane was blocked so many miles ahead or that traffic was "slow" or was "OK?"

No Answer	0	0 %
Yes	130	94 %
No	9	6 %

3. The sign sometimes displays "Lane Blocked, so many miles ahead" telling you when there has been an accident or incident further ahead toward downtown. Have you seen this message?

No Answer	4	3 %
Yes	81	58 %
No	54	39 %

4. If your answer to Question 3 was "Yes," please answer this question. When the "Lane Blocked" message was displayed, which of the following did you do?

No Answer	58	42 %
I slowed down and continued with caution.	61	44 %
I left the freeway and took another route because of the congestion.	9	6 %
I left the freeway and took another route because of the sign message.	9	6 %
I left the freeway and used the frontage road because of the congestion.	0	0 %
I left the freeway and used the frontage road because of the sign message.	2	2 %

5. Have you ever left the freeway and used the frontage road or alternate route because of any message displayed by the electronic sign?

No Answer	4	3 %
Yes	39	28 %
No	96	69 %

6. Have you ever left the freeway and used the frontage road or alternate route to bypass congestion?

No Answer	2	1 %
Yes	97	70 %
No	40	29 %

7. Sometimes the sign suggests that you should "Keep Right" or "Keep Left." Have you ever made a lane change from one lane to the next because of these messages being displayed?

No Answer	7	5 %
Yes	81	58 %
No	51	37 %

8. Suppose the electronic sign were moved to south of the South Loop (I-610) interchange. The sign would be located inbound on the Gulf Freeway. If the sign said "Gulf Freeway Lane Blocked 2 Miles Ahead," what would you do?

No Answer	13	9 %
I would probably continue driving on the Gulf Freeway because I have no other good route to my destination.	53	38 %
I would take the South Loop to work if this were the rush hours.	17	12 %
I would take the South Loop to my destination if it were convenient.	42	31 %
I doubt the sign is accurate and would not pay any attention to it.	0	0 %
I don't know what I would do.	14	31 %

9. Age

No Answer	2	1 %
Under 25	26	19 %
25 - 44	62	45 %
45 or Older	48	35 %

APPENDIX C

SUMMARY OF SIGNIFICANT MOTORISTS' COMMENTS

Selected comments, both solicited and unsolicited, from motorists queried are included in this Appendix, and are preceded by the questions which drew each comment.

When the sign does not display any message, what does it mean to you?

1. Sometimes that the equipment has failed because it says that the traffic is OK when it is stacked up bumper to bumper from about College Street to Dumble or Scott. Some of these times it takes as long as an hour to an hour and one-half to get to town when normally it would be a thirty-minute drive.

During off-peak periods, the sign usually displays the word "OK," meaning traffic flow ahead is normal. Do you feel that this message is useful?

1. No display unless there is an accident or congestion.
2. Lets me know sign is operative.
3. Suggest normal or clear
4. Does not matter because traffic is always bad.

Would you prefer instead that no message be displayed?

1. Depends on cost, regardless not much can be done any other way.

During off-peak periods, the sign sometimes states "Slow Traffic, so many miles ahead" telling you how far ahead to expect congestion. Do you feel that this message is useful?

1. Depending on the time of day, I expect slow traffic in the morning.
2. Not for me as I have no alternate route.
3. Traffic is usually slow before you reach the sign.

The sign displays "Lane Blocked, so many miles ahead" when there has been an incident or accident further ahead. Do you feel this message is useful?

1. Would be helpful to know which lane is blocked so you could avoid it.
2. If the feeders were open you would have an opportunity to get off the freeway.
3. Would help if it said which lane and whether before or after 59 cut-off.
4. Many times it says that the traffic is clear and the traffic is congested. Many times there has been an accident or something and nothing is said except traffic OK. Twice this month there were four car collisions and there was no warning. If there were, I would not have gotten to work two hours late because of two lanes blocked up.

5. Very much.
6. This should be placed at least five miles back and let traffic flow change lanes more easily and safely.
7. You are usually not able to get out of your lane during peak periods.
8. Very.

When the lane blockage is only 1 mile ahead, the sign occasionally tells you to "Keep Left" or "Keep Right" as necessary to avoid the blocked lane. Do you feel this message is useful?

1. You are usually not able to get out of your lanes during peak periods.
2. Any useful information helps.

Another possibility when a lane is blocked and you are not yet on the freeway is a message which tells you to "use the frontage road" and thus avoid the congestion. Do you feel this message is useful?

1. The frontage roads do not go straight through to town so it does not help me when I use them.
2. Lights are congested and railroad tracks cause long detours. It's not worth it.
3. Would be if we could use service road.
4. Useful to those not already on freeway. I am interested in any improvements.

Have you seen the messages in Questions 6, 7, and 8 displayed?

1. No, I get on the Gulf Freeway from 225. It would be helpful to know before trying to get on U.S. 45 if traffic ahead is bad. A sign like the one described as above would be helpful to us on 225 so we can take alternate routes instead of congesting the traffic more on 45.
2. No. Signs should be overhead as they cannot be read from the left lane at times.

Can you think of better messages for the above?

1. Lane number.
2. Right, left, or center lane blocked.
3. Flashing message when accident on freeway
4. An accident ahead. This is very good. Please improve the warning signs on freeway as speed limits concentration. People are being killed for lack of clear warning.
5. Idea is excellent but improvement needed.
6. Which exit to use.

Sometimes the sign displays a message that reads "FREEWAY CONDITION X." In your opinion this means that the freeway traffic condition ahead is: (Answers: Very good, good, fair, etc.)

1. This is what I was talking about. Have never been clear what messages meant. I have deduced that traffic C probably means congested.
2. According to my experience. Comment - Previously I never thought of the letters as indicating the degree of congestion.

During rush hour traffic, the flow of traffic on the Gulf Freeway is frequently slow, sometimes bumper-to-bumper. The condition of traffic ahead may also be slow. Under these conditions, which of the following messages would you feel is most meaningful to you to describe this situation? (Answers: "Slow traffic, so many miles ahead," "No message displayed," etc.)

1. None. Frankly the messages do not do me much good at all as I can only go to work one way so they do not help me at all.
2. Just say what it is -- Slow all the way to town or Slow Traffic to Scott, etc.

It is possible to determine and display on the sign the number of miles ahead the traffic condition will improve to a normal driving speed. Would you be interested in having this information displayed while you are traveling in slow traffic?

1. It would do little good. It would stay bumper to bumper. People should be more considerate and let cars enter traffic flow. Trucks should stay in one lane. It could be worse though.
2. This way I can get off and take an alternate route.
3. This will let me know if I want to stay on and go slow or get off and go another way.
4. Means very little if your exit is before congestion or if you are very late to work.

In your driving experiences on the Gulf Freeway, which of the following statements would best describe your reactions to the signs? (Answers: I understand them and use the information; I understand them, but do not use the information much; etc.)

1. In general I do not understand most of the messages and in questioning many of my friends they are of the same opinion.
2. Sometimes the signs say slow traffic - Fwy. Condition B or C. What do the grades mean? I do not understand the grades.
3. I have never seen any message except Fwy. cond. A & C. I'll watch it more carefully in the future.
4. I understand all except some of the letter grades but do not use the information much. I believe these signs should only show positive information that is not already obvious to the driver.
5. I could use it more if sign were further out freeway where most congestion is (Gulfgate Area) and I would have time to reroute my drive.

If c., (I do not understand some of the messages and so am not able to use them) specify which messages are not understood.

1. I have never received any information regarding the letter grade rating system.
2. Suggest media posting of what letters signify.
3. I do understand, but visitors and illeterates might not.
4. Slow traffic two miles ahead - Does it mean it will get worse in two miles or that the slow traffic will be over by then?
5. One knows when the traffic is slow - the only message that would be meaningful is what lane is blocked ahead due to stalled car or accident.
6. The messages I have seen are very useful and I try to use them.

7. Use of letters is confusing. Stick with "OK" and phrases as such.
8. I appreciate them.

In general, my overall evaluation of the signs is as follows: (Answers: Very useful as they are; Useful, but could be improved; etc.)

1. Messages are useful but should be located near or before Gulfgate.
2. Need more signs.

GENERAL COMMENTS

1. In my opinion the sign should be placed around Park Place or Bellfort. By the time I reach Telephone and Wayside the traffic is usually smooth. If an accident has occurred the congestion forms around Gulfgate. If the signs were placed further south there are many more alternative routes.

2. Most times sign indicates Fwy. Condition A-OK. There seems to be a point at which individuals would ignore the sign because of its inconsistency. Periodically it would appear that something could be done to indicate to the driver that the sign was not broken.

3. I do not remember ever having seen the sign say freeway condition F. I have moved from Harrisburg and I think that all information signs on freeway are very useful. I also like the speed limit.

4. I suggest that you put up another sign between Park Place and Loop 610. This could possibly ease some of the traffic jam at 45 and 610.

5. I believe the traffic engineers are doing a fine job. I would be helpful if drivers would use middle or outside lanes to go slower than the other traffic.

6. The idea behind this is great. I observed the installation of the signs and was looking forward to their operation. However I have been disappointed. I get on the freeway every morning at the Wayside approach. This morning (Nov. 8, 1974) the approach sign read "Fwy. Condition C-OK" and I waited about five minutes to get on the freeway. On top of the overpass a Volkswagon was stalled. The traffic was very slow, and on occasions at a complete stop. The large sign on the freeway read the same as the small approach sign. The only messages I have seen have been Freeway Conditions A-OK, B-OK, or C-OK - next 2 miles. On some rare occasions it has read "Slow Traffic." On one such occasion I made the trip from Wayside to my office at Main and Dallas in ten minutes - "Very first time."

7. I drive a truck transport for Texaco and feel that the signs are very helpful. Need to have similar signs on all freeways.

8. Sign would be more useful if suspended above freeway.

9. The messages on the board should be flashed at certain intervals of time rather than one continuous lighted message because the sign and the lights cannot be used efficiently by oncoming or approaching motorists. Why? Because the sign and lights blend in with the background of other businesses thereby obscuring it. With the messages flashing, motorists can detect the sign from a distance with better attention from the majority of passing motorists from any of the present lanes of traffic, thereby allowing a reasonable amount of time for motorists to rationalize the message and situation ahead.

APPENDIX D

REPRODUCTIONS OF COMPUTER PRINTOUTS OF ANALYSIS INCIDENTS

APPENDIX D-1

REPRODUCTION OF COMPUTER PRINTOUT

OF "LANE BLOCKED" ANALYSIS INCIDENT

Data tabulated for traffic response to "LANE BLOCKED" display during incident conditions are as follows:

T = time (24-hour clock)

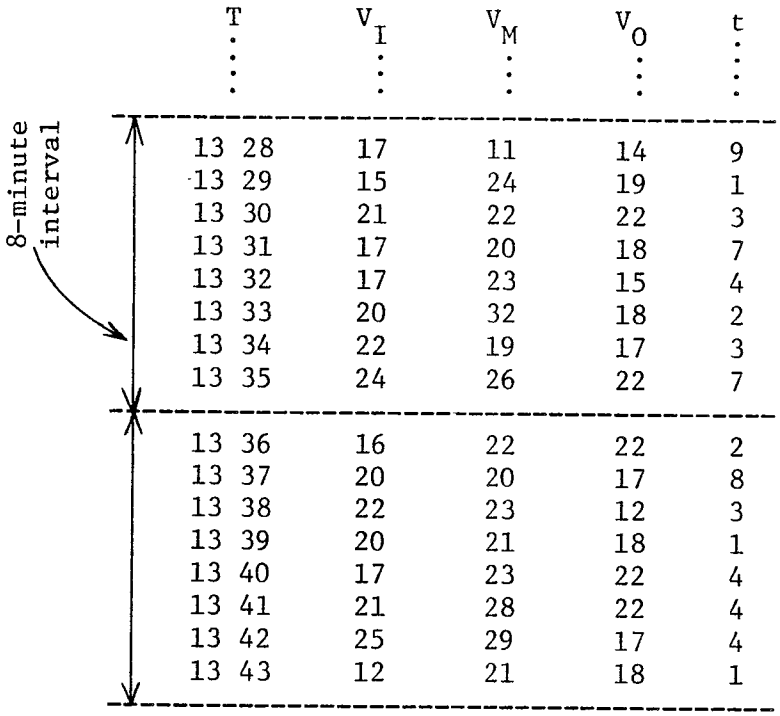
V_I = inside freeway lane volumes

V_M = middle freeway lane volumes

V_O = outside freeway lane volumes

t = Telephone exit ramp volumes

T	V_I	V_M	V_O	t	
13 4	20	22	18	3	8-minute intervals
13 5	17	23	18	4	
13 6	15	27	22	6	
13 7	18	17	20	3	
13 8	15	24	17	4	
13 9	24	26	24	3	
13 10	22	22	25	6	
13 11	23	25	22	3	
13 12	21	21	20	4	
13 13	18	22	20	3	
13 14	16	18	16	6	
13 15	14	21	18	3	
13 16	26	25	26	4	
13 17	24	31	20	7	
13 18	29	24	27	1	
13 19	16	15	17	7	
13 20	14	8	6	10	Duration of Incident
13 21	14	14	7	26	
13 22	15	12	14	14	
13 23	11	13	12	14	
13 24	8	8	15	19	
13 25	9	8	17	11	
13 26	12	12	14	19	
13 27	8	3	6	11	



T	V_I	V_M	V_O	t
13 28	17	11	14	9
13 29	15	24	19	1
13 30	21	22	22	3
13 31	17	20	18	7
13 32	17	23	15	4
13 33	20	32	18	2
13 34	22	19	17	3
13 35	24	26	22	7
13 36	16	22	22	2
13 37	20	20	17	8
13 38	22	23	12	3
13 39	20	21	18	1
13 40	17	23	22	4
13 41	21	28	22	4
13 42	25	29	17	4
13 43	12	21	18	1

APPENDIX D-2

REPRODUCTION OF COMPUTER PRINTOUT

OF ANALYSIS INCIDENT IN ABSENCE OF SIGN DISPLAY

Data tabulated for traffic response to incident conditions in the absence of a sign display are as follows:

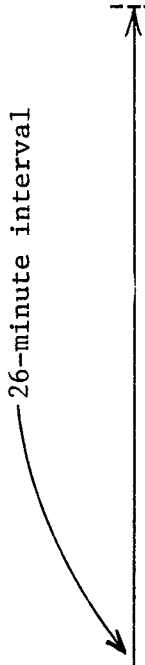
T = time (24-hour clock)

V_I = inside freeway lane volumes

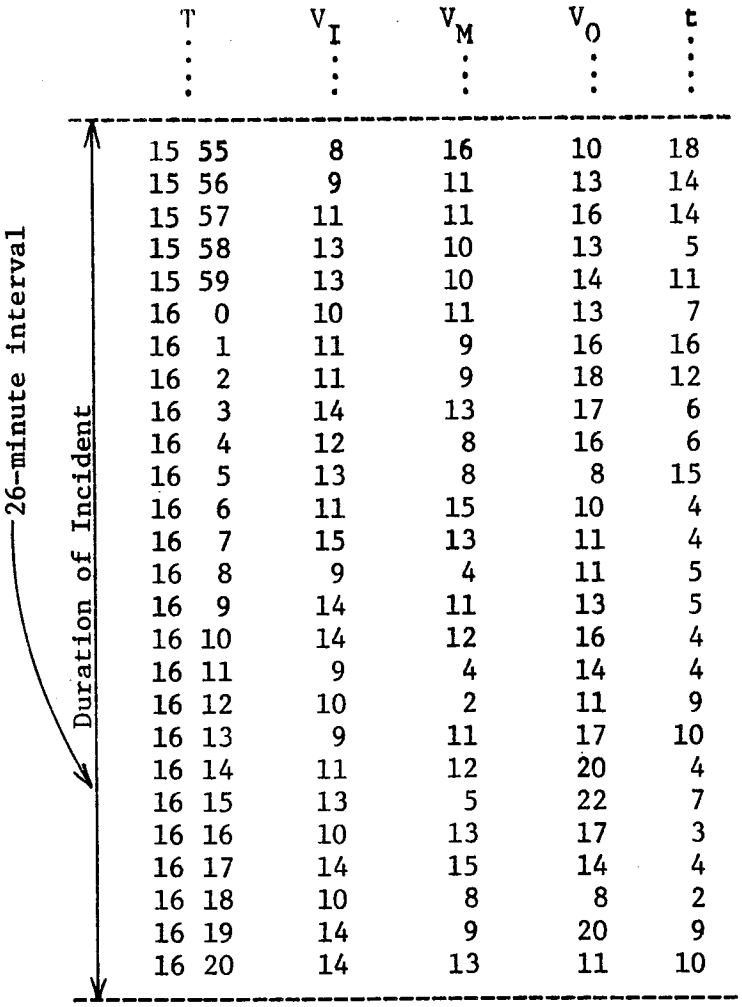
V_M = middle freeway lane volumes

V_O = outside freeway lane volumes

t = Telephone exit ramp volumes



T	V_I	V_M	V_O	t
15 29	40	38	30	6
15 30	30	31	23	5
15 31	33	38	39	2
15 32	32	35	32	8
15 33	26	22	31	3
15 34	30	30	31	4
15 35	26	26	27	4
15 36	29	31	29	8
15 37	20	28	37	6
15 38	30	32	30	1
15 39	33	35	32	1
15 40	33	27	34	3
15 41	21	31	38	3
15 42	26	30	25	1
15 43	30	31	26	2
15 44	31	33	32	5
15 45	24	31	22	3
15 46	29	28	33	6
15 47	25	27	30	2
15 48	24	26	22	4
15 49	25	23	25	4
15 50	28	30	31	3
15 51	23	27	31	4
15 52	29	32	30	2
15 53	22	24	28	3
15 54	20	23	25	9



T	V_I	V_M	V_O	t
15 55	8	16	10	18
15 56	9	11	13	14
15 57	11	11	16	14
15 58	13	10	13	5
15 59	13	10	14	11
16 0	10	11	13	7
16 1	11	9	16	16
16 2	11	9	18	12
16 3	14	13	17	6
16 4	12	8	16	6
16 5	13	8	8	15
16 6	11	15	10	4
16 7	15	13	11	4
16 8	9	4	11	5
16 9	14	11	13	5
16 10	14	12	16	4
16 11	9	4	14	4
16 12	10	2	11	9
16 13	9	11	17	10
16 14	11	12	20	4
16 15	13	5	22	7
16 16	10	13	17	3
16 17	14	15	14	4
16 18	10	8	8	2
16 19	14	9	20	9
16 20	14	13	11	10