REAL-TIME INFORMATION NEEDS FOR URBAN FREEWAY DRIVERS

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Research Report Number 139-4

Freeway Control and Information Systems Project
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Sponsored by

The Texas Highway Department
In Cooperation with the
U. S. Department of Transportation
Federal Highway Administration

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

August 1970

ABSTRACT

To broaden the application of real-time freeway operations systems, the Texas Transportation Institute and the Texas Highway Department, in cooperation with the U. S. Department of Transportation, began a research project entitled "Freeway Control and Information Systems." One of the objectives of the project was to develop functional requirements for a freeway communications system. Toward this end, a questionnaire survey was conducted in the cities of Houston and Dallas. This report discusses the results of the survey which was directed at the evaluation of the following:

1. Driver attitudes toward the need for real-time freeway information
2. Potential use of and response to real-time freeway information
3. Driver preferences for mode of communication
4. The type of information desired by the freeway driver
5. Driver priorities regarding the locations where information would be most useful
6. Driver comprehension of and preferences for visual displays

DISCLAIMER

SUMMARY

This report pertains to research findings of a portion of Project 139 entitled "Freeway Control and Information Systems." One of the objectives of the project is to develop functional requirements for a real-time freeway communications system. Toward this end, it was deemed essential that the motoring public should play a major role in establishing the design of the system, since the system must fulfill their needs. Consequently, a comprehensive questionnaire and slide presentation were designed by a multidisciplinary team. The questionnaire was administered to 505 employees of several organizations in Houston and Dallas.

The following findings may be drawn from the evaluation presented in this report:

1. Urban freeway drivers desire additional traffic information which is not currently provided by passive signing. They also considered real-time traffic information as having considerable potential in meeting their overall information needs.

2. Freeway motorists would react to real-time information by rerouting to the nearest and best available alternate route. The majority prefer to use the alternate route only to by-pass congested areas on the freeway. Most freeway drivers prefer to return to the freeway.

3. Motorists are more inclined to divert to an alternate route before they reach the freeway than once on the freeway.

4. The two information descriptors most preferred were 1) the location and length of the congested area and 2) the degree of congestion. Seventy-one percent of the respondents selected the former descriptor, and 69 percent selected the latter. The reason for the congested area, such as an accident, maintenance, stalled vehicle, etc., was preferred by 40 percent of the motorists. The quantitative descriptors of travel time and travel speed were the least preferred, having been selected by only 7 and 13 percent, respectively.

5. Commercial radio and changeable message signs were preferred over telephone and television services. There did not appear to be any appreciable difference between the preference for changeable message signs and the preference for radio. (See reference 11."

6. Motorists prefer to receive information about freeway traffic conditions before they enter the freeway. The following constitutes the ranking of preferred locations for communications:

    1. On the major street
    2. At the entrance ramp
    3. At the beginning of trip
    4. On the freeway

7. Motorists prefer a real-time information sign display that is simple in nature. Simple type displays were consistently

preferred over designs containing a diagram that provided the motorists with an orientation of the freeway and streets. The following designs were consistently rated high:

1. Design 1 - A sign containing words and color indications to describe the traffic conditions

2. Design 2 - A sign portraying only color indications to reflect the traffic conditions

The following designs were consistently rated low:

1. Design 3 - A sign depicting a diagram of the area, using illuminated color symbol indications to show the traffic conditions

2. Design 4 - A sign illustrating a diagram of the area, giving travel speeds between reference points

8. It was not possible to draw any definite conclusions from the analysis performed on words that describe freeway traffic conditions. However, the data suggest that the use of different word descriptors is desirable to distinguish abnormal conditions during the peak from those during the off-peak.

9. The terms "normal or normal traffic" were considered as the preferred descriptors of usual conditions encountered during both the off-peak and peak periods. Fifty percent of the motorists selected one of these two descriptors.

10. Motorists prefer a unique design that distinguishes real-time visual displays from other types of freeway signing.

11. Motorists prefer unique design features, such as the use of color, on visual displays to distinguish between usual and abnormal traffic conditions.

12. There was no reason to believe that there was a preference for any of the following symbols which could be used on a real-time visual display: circle, arrow or bar.

13. In general, the difference in response was insignificant between the group commuting to work via the freeway and those individuals who do not use the facility.

14. In general, there was no significant difference in response between the individuals who prefer to drive the city streets and those who prefer the freeway.

Implementation

The results and findings of this study will serve as a base for the design of a real-time information system for urban freeways. The following paragraphs describe some functional requirements of a system based on this research.

1. *Real-time information should be provided to the motorists at the following locations: 1) on the major streets, 2) at the entrance ramps, 3) at the beginning of the trip, and 4) on the freeway*. Motorists prefer to receive information about freeway traffic conditions before they reach the freeway.

The probability of diversion is greater before they reach the freeway than once on. Motorists are more reluctant to divert after they have entered the freeway; therefore, some emphasis should be given for the provision of communication information at locations off the freeway, where decisions can be made regarding diversion to alternate routes.

2. *The system should inform the motorists of the degree of congestion and the location of the congested area.* These were the preferred descriptors. Information pertaining to the reasons for the congestion, such as an accident, might be helpful but do not appear to be necessary. Travel time and/or travel speed do not seem to convey the desired information.

3. *Real-time visual displays should be simple in nature and should not contain diagrams of the freeway and street system.* Motorists prefer signs that have basically simple displays. Signs that displayed street diagrams received low ratings.

4. *Descriptors provided to the motorists must be such that different wording (if words are used) should be used to distinguish the traffic conditions on the freeway during the peak period from those during the off-peak period.*

5. *Color, or other pronounced characteristics, should be used on a sign display to distinguish between usual and abnormal traffic conditions.*

6. *A unique sign design should be employed that distinguishes real-time visual displays from other types of freeway signing.*

7. *Suitable and well marked alternate routes must be available for the diversion of traffic around major incidents on a freeway.* The success of any diversion will be dependent upon the availability of good alternate routes. These routes must become a part of the overall control and communication system. If these routes are to be effective, their intersection signals must be integrated with the freeway control and communication system. Most freeway drivers prefer to return to the freeway; therefore, diversion techniques should re-direct them to the freeway if possible.

ACKNOWLEDGMENTS

The success of this phase of the project is due to a large extent on the cooperation of several organizations. The authors wish to gratefully acknowledge the direct assistance and information given by the following individuals who represented these organizations:

From the City of Houston

American Automobile Association
Mr. Rick Timmens

City Hall
Mr. Fred Homes
Mr. Jerry King

Houston Lighting and Power Company
Mr. Craig McNease
Mr. Ted Means

Humble Oil and Refining Company
Mr. David Johnson
Mr. E. W. Hamilton

Southwestern Bell Telephone Company
Mr. John Tipple
Mr. Lee Doyle

Texas Highway Department; District 12 Office
Mr. Dale D. Marvel
Mr. R. G. Biggs

Texas Highway Department; Urban Office
Mr. W. L. McClure

Transcontinental Gas Pipe Line Corp.
Mr. Jack O'Neal

University of Houston
Dr. Jack Rhodes

From the City of Dallas

City Hall
Mr. John DeShazo
Mr. Kenneth Hufford
Mr. John Mayo

Dallas Power and Light Company
Mr. W. W. Aston

Southwestern Bell Telephone Company
Mr. C. F. Weekly

Texas Highway Department; District 18 Office
Mr. R. Yielding

Texas Instruments
Mr. John Jones

Deserving special mention are the 505 employees from these organizations who participated in the questionnaire survey.

The success of the questionnaire was attributed to the many staff members of the Texas Transportation Institute (TTI) and the Texas Highway Department who participated in the design of the questionnaire. The authors are grateful for the valuable assistance of the following persons: Mssrs. W. R. McCasland, M. E. Goolsby, J. Carvell, M. Edwards and Drs. C. Messer and N. Ellis of TTI and Mssrs. D. D. Marvel, R. G. Biggs, and R. Yielding of the Texas Highway Department. Acknowledgment is also due to Dr. H. O. Hartley, Director of the Department of Statistics, Texas A&M University, for his assistance in organizing the questionnaire from a statistical standpoint.

The authors extend special acknowledgment to Mr. G. Dresser, Research Statistician, TTI, for his assistance in the statistical analysis of the data.

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BACKGROUND

Introduction

During the last decade, freeway control has evolved from a research experiment to an operational reality. The metering of freeway demand on entrance ramps has proven to be an effective means of improving the operational efficiency of an overcrowded freeway and can now prevent the breakdown of a freeway under "usual" conditions. However, the occurrence of an incident, such as an accident or stalled vehicle, reduces the effective capacity considerably and over-taxes a freeway control system to the extent that the system cannot effectively control the demand. If the traffic demand could be redistributed in time and space, improvements in the level of service could be realized. This will require some type of real-time information system that would enable the driver to intelligently choose a suitable route from the alternatives available to him.

To broaden the application of real-time freeway operations systems, the Texas Transportation Institute and the Texas Highway Department, in cooperation with the U. S. Department of Transportation, began a research project entitled "Freeway Control and Information Systems." This project is an outgrowth of previous research on the Gulf Freeway in Houston, Texas, which culminated in an operational freeway ramp control system.

Objectives

One of the objectives of the project is to develop functional

requirements for a freeway communications system. Toward this end, it was deemed essential that the motoring public play a major role in establishing the functional requirements of the system, since the system must fulfill their needs. This report discusses research directed at evaluating the following items:

1. Driver attitudes toward the need for real-time freeway information
2. Potential use of and response to real-time freeway information
3. Driver preferences for mode of communication
4. The type of information desired by the freeway driver
5. Driver priorities regarding the locations where information would be most useful
6. Driver comprehension of and preferences for visual displays

Status of Real-Time Driver Communications for Urban Freeways (1)

During the last decade, several prototype communications devices which would provide the driver with real-time freeway information have been installed and tested. Most of these systems have been designed on the basis of the researchers' concepts of what they felt the configurations of the systems should be. Very little input with respect to comprehension and attitudes was provided by the motoring public prior to the installations. In most cases, feedback was obtained by measuring the motorists' reactions after the devices had been installed.

Lane control has been attempted through the use of a red "X" and green arrow to inform the freeway motorists whether a particular lane

was closed or open ahead (2). Studies have shown that the effectiveness of these signs appeared to be a function of the freeway demand (3). The effectiveness was reduced considerably when the freeway demand exceeded the capacity of the obstructed section.

Variable speed message signs have been used in some instances. The results of studies by the Texas Transportation Institute (3) indicated that the motorists did not decrease their speeds to coincide with the posted speed unless there was an apparent reason to do so. Another study conducted by the California Transportation Agency (4) concerning the applicability of the variable speed sign to traffic control during fog conditions concluded that posted speeds less than 35 to 40 mph had little effect in reducing speed.

Some forms of changeable message displays, which have been installed on major streets near a freeway to inform the drivers of the freeway traffic conditions, have been evaluated. Hoff (5) found that very little diversion was attributed to the information signs used in Chicago. He noted, however, that divergent results had emerged, since a questionnaire study indicated that a large proportion of the drivers did use the signs. Studies conducted by the Texas Transportation Institute in the Lodge Freeway corridor in Detroit (6) indicated that the information signs used in Detroit were cost-effective. The effectiveness was based on travel time savings. The University of Michigan (7) is currently evaluating additional signs which have been installed in the Lodge corridor. However, the research is still in progress and as of this date no results have been published.

Commercial radio is another form of communication that has been used in many large cities to disseminate information on freeway traffic conditions. However, very little has been done to evaluate this mode of communication.

Perhaps the first attempts to evaluate driver attitudes toward real-time freeway traffic information were the studies conducted by Heathington, et. al, (8, 9). A total of 732 drivers were interviewed by means of a home interview survey conducted in the Chicago metropolitan area. The results of the study indicated the following:

1) Information on traffic conditions seemed to be relatively important while driving on an expressway, but unimportant while driving on a city street.

2) The provision of additional radio traffic reports was of a very low priority nature.

3) For all levels of congestion, traffic information was preferred over no information about traffic conditions.

4) For the level of heavy congestion, information relative to an accident having occurred causing heavy congestion was the most preferred descriptor of the total sample.

5) The descriptor "speed" ranked second to the "accident" descriptor for heavy congestion conditions and was the first choice for moderate and uncongested conditions.

6) The two quantitative descriptors of "delay" and "travel time" had relatively low scale values and were simply not desired by the respondents.

Approach to the Problem

The design of a passive (fixed messages) freeway visual communications system has long been problematic because, in some cases, the information provided does not orient and stimulate the driver to the extent that he can select and make the response required for safe and efficient traffic operation under the prevailing traffic conditions. This deficiency has arisen because the designers were not always certain of the motorists' reactions after the sign or signs were installed. Means are currently being sought to identify the deficiencies in designs of passive visual communications systems and to recommend changes in the existing standards. This is being accomplished by involving the driver in the analysis and by using this feedback information for effective analysis and design. One such study, which involves freeway signing, utilizes a "diagnostic" approach (10).

Similar types of problems exist in the design of a real-time freeway information system. The system must stimulate appropriate driver responses. It must be designed such that the information is meaningful, timely, and useful to the driver. It was reasoned, therefore, that the motoring public should play a major role in establishing the system design, since the system must fulfill their needs. Feedback information would be valuable for effective design. Therefore, a questionnaire

survey was designed and conducted to obtain inputs from the motoring public.

The questionnaire was designed by a multidisciplinary research team with individuals having expertise in traffic and transportation engineering, psychology, human factors engineering and statistics. Since the questionnaire was to be administered to employees of organizations during working hours, time was of the essence. It was, therefore, carefully designed so that it could be completed in approximately 40 minutes.

The questionnaire was divided into three parts. The social and driving characteristics of the participants were obtained from Part I. Part II was designed to evaluate driver attitudes and preferences with respect to real-time freeway information in general. In Part III a slide presentation was made, in conjunction with the questionnaire, to evaluate driver comprehension of and preferences for visual displays. The questionnaire is reproduced in Appendix A.

Administration of the Questionnaire

The questionnaire was pretested by administering it to two different groups of individuals totaling 40 persons. As a result of the pretesting, a few revisions were made to facilitate better statistical analysis.

The questionnaire was designed for the population of motorists who drive daily in a large metropolitan area serviced by several freeways. The cities of Houston and Dallas were chosen as locations for the conducting of the survey.

Several business organizations were asked to participate in the survey by permitting the questionnaire to be administered to a random group chosen from their employees. Instructions specified that the group be made up of individuals from both sexes, various age groups and various levels of education. The only restrictions were that they must be licensed drivers and that no one with experience in traffic engineering or anyone who had worked with highway signing could participate.

One staff member from the Texas Transportation Institute administered the questionnaire to all groups. So that no bias would be introduced in giving separate presentations, an introduction and special instructions for answering the questionnaire were read by the staff member. In so doing, each group received the same information. The order of presentation for Parts II and III was alternated each time the questionnaire was administered, to reduce any bias in the response to questions in either part.

The questionnaire was administered to a total of 17 different groups. From these groups a total of 505 licensed drivers participated, 329 from the city of Houston and 176 from the city of Dallas.

Data Reduction and Analysis

For purposes of simplifying and permitting flexibility in the analysis, the data were coded and transferred to computer cards. A computer program was then written to analyze each question separately, from either the total sample or various subgroups. The analysis of these questions was based upon the number responding to each question and does not necessarily equal the total number of participants.

Consequently, the results of each question will be shown in terms of percentages of those who did respond to the question.

Characteristics of Participants

Some of the social and driving characteristics of the participants who took part in the questionnaire survey are summarized in Table B-1 of Appendix B. Of particular relevance to this study are the characteristics relating to the use of and preference for the freeway to travel in urban areas. Eighty-two percent of the participants indicated that they drive on the freeway more than five times per week, while 97 percent indicated the use of a freeway at least one time each week. Of the total sample, 70 percent normally used the freeway to commute to and from work, and 90 percent indicated a preference to drive the freeways within the urban areas in contrast to city streets.

There had been some speculation that the response of those who do not use the freeway for their work trips might differ from those who do. Similarly, the preference for driving the city streets may have influenced the response by some participants. Consequently, in addition to analyzing the total sample in this study, analyses were also made for these various subgroups. The findings from these subgroup analyses are discussed later in the report.

It was of interest to compare some of the characteristics of the sample to the driving populations in Texas and in the United States. Comparisons of the distributions by age and sex are presented in Tables B-2 and B-3, respectively, of Appendix B. The results show that the distribution by age of the sample compared favorably with that of the

driving populations in Texas and in the United States. The results also show that the sample was slightly over-weighted with male drivers in comparison to the total driver populations. In addition, the proportion of female drivers in the sample is slightly biased towards the lower age group. The discrepancies noted would be expected, since the questionnaire was administered to employees, which excludes those drivers such as housewives, etc.

It would have been desirable to compare these characteristics of the sample to the freeway driving population. However, the population data were not available.

ANALYSIS OF DATA

Driver Attitudes toward the Need for Real-Time Information

The evaluation of driver attitudes toward the need for the real-time information was accomplished by asking the participants to allocate $100,000 for improvements pertaining to the existing signing for a freeway within a city. The choices included the following: provide additional guide signs; provide freeway real-time information; others (for write-in suggestion). The additional guide signs item was provided since it was felt that the participants should have some known basic freeway information for comparison. Table 1 illustrates the participants' distributions of the allocated money. The write-in suggestions for the "other" category are summarized in Table 2.

The results show that 95 percent of the respondents allocated 67 percent of all the available money for providing real-time information. The mean amount spent by the respondents for real-time information was $70,000, compared to $37,000 and $45,000 for additional guide signs and "other," respectively.

These results indicate that drivers feel that need for additional traffic information which is not provided by passive signing. They also indicate that the respondents considered real-time traffic information to have very favorable potential in meeting their overall information needs.

Potential Use of and Response to Real-Time Freeway Information

Several questions were included in the questionnaire to evaluate the potential use of and reaction toward real-time information.

Table 1

PARTICIPANTS' ALLOCATION OF MONEY FOR IMPROVEMENTS IN FREEWAY COMMUNICATION

Item	Percent of Total Responding to Item	Total Money Spent on Item (Thousands of Dollars)	Percent of Total Money Spent	Average Amount Spent
Additional Guide Signs	68	$ 12286	25	$ 37,000
Real-Time Information	95	32249	67	70,000
Others (Written Comments)	18	3965	8	45,000

Table 2

COMMENTS ON ALLOCATION OF MONEY TOWARD IMPROVEMENTS

Recommendations	Respondents (%)
More freeways or improvement of existing freeways	2.6
Providing real-time information by radio	1.8
Better freeway law enforcement	1.4
More freeway lane markings	1.0
Research for better signing techniques	1.2
Providing a better means of transportation	0.8
Educating the freeway driver	0.8
Additional signing of freeway and street	3.8
Other Miscellaneous facilities which would aid the freeway driver	3.8
TOTAL	17.0

One measurement of the potential use was made by requesting that the participants indicate the frequency with which they would use accurate information about the freeway conditions to plan their trips. The following four choices were given: 1) always, 2) frequently, 3) occasionally, and 4) never. The participants' responses are presented in Figure 1.

The results show that 47 percent of the respondents indicated that they would always use freeway traffic information, provided it were accurate, and 38 percent responded that they would frequently use the information. Thus, 85 percent would make frequent use of the information to plan their trips.

Another set of questions included in the survey placed the participants in hypothetical situations. They were to assume that a major street was available as an alternate route which they could travel instead of the freeway. They were asked whether they would use the alternate route if informed that freeway traffic was moving slower than usual for that time of day. Three situations were given: 1) if they were informed before they entered the freeway and the event occurred during the peak period 2) if they were informed while traveling the freeway and the event occurred during the peak period and 3) if they were informed while traveling on the freeway during the off-peak period. The results of the responses to these hypothetical situations are summarized in Table 3.

The results indicate that the majority of the motorists sampled would be inclined to divert from the freeway if they had prior knowledge of an unusual condition on the freeway and provided a suitable

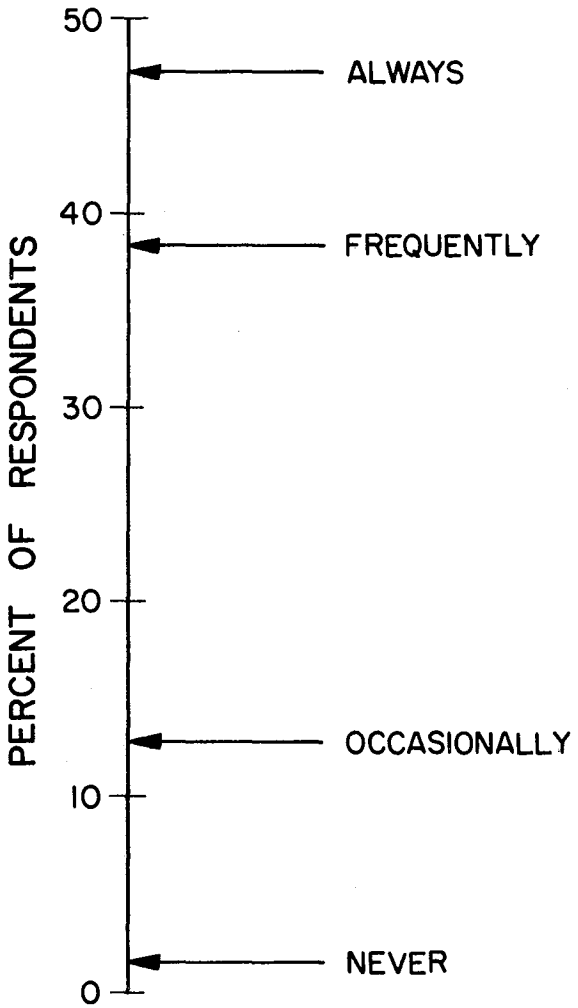


FIGURE 1 - DRIVER USE OF REAL-TIME FREEWAY INFORMATION

Table 3

SUMMARY OF PROBABLE DIVERSION TO AN AVAILABLE MAJOR STREET ASSUMING INFORMATION WAS AVAILABLE REGARDING AN UNUSUAL CONDITION ON THE FREEWAY

	Alternative	Respondents (%)
Condition:	Peak Period; Information Given Before Entering Freeway	
	Would Divert	92
	Would Not Divert	8
Condition:	Peak Period, Information Given After Entering Freeway	
	Would Divert	75
	Would Not Divert	25
Condition:	Off-Peak Period; Information Given After Entering Freeway	
	Would Divert	70
	Would Not Divert	30

alternate route were available. They would be more inclined to divert to an alternate route before they reached the freeway than they would once on the freeway. Ninety-two percent of the participants indicated that they would use the available alternate route along a major street during the peak period if they were informed of the unusual traffic condition before they entered the freeway, whereas 75 percent said that they would divert once on the freeway. If the condition occurred during the off-peak periods, 70 percent stated that they would be inclined to use the major street.

The reactions of the motorists to real-time freeway information were further evaluated by questions asked during the slide presentation in Part III of the survey. The participants were placed into three different driving situations.

In the first situation, the participants were requested to assume they were driving along a major street which runs parallel to the freeway and that they were at the point marked by the X, as shown in Figure 2. Their intended route was to turn right at Smith Avenue, proceed to the freeway and then turn north onto the freeway. For some reason, the northbound lanes of the freeway between Smith Avenue and Brown Avenue had become heavily congested, as shown. This congestion would cause extra delay in their trip if they continued to use the freeway. Changeable message signs located in advance of the intersections of the major streets would inform the drivers of the existing condition on the freeway. (It is recognized that signs are not the only mode of communication which could be used to communicate with the driver. However, use of signs seemed to be the most effective way of showing to the participants by slide presentation that real-time information would be available to

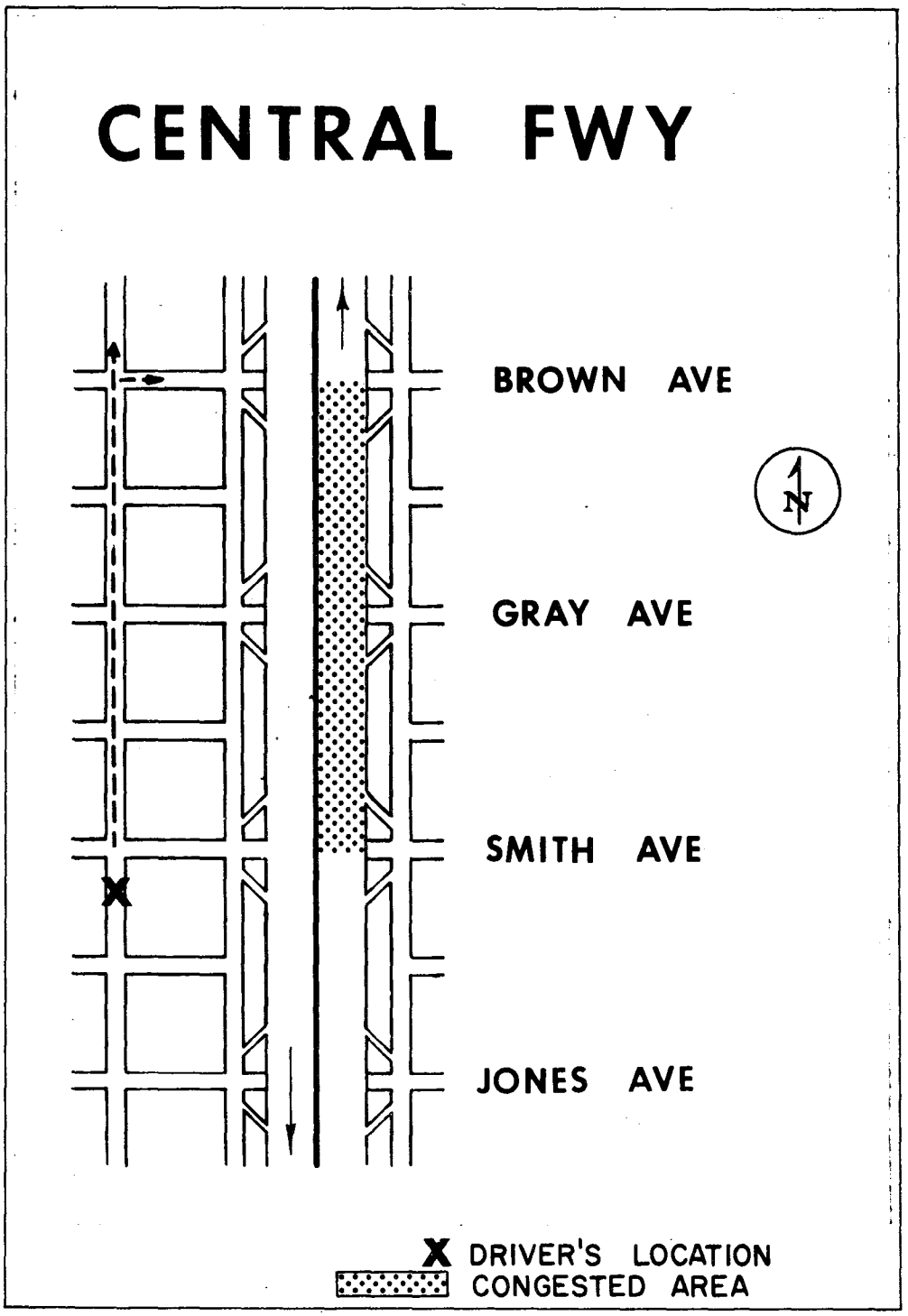


FIGURE 2—SCHEMATIC OF HYPOTHETICAL SITUATION—DRIVER ON PARALLEL MAJOR STREET

them.) The participants were then presented the following choices to indicate their reaction: 1) when pressed for time and 2) when not pressed for time:

A - Proceed to the freeway and enter the main lanes at the Smith Avenue on-ramp

B - Proceed to the freeway and use the service road to bypass the congested area

C - Remain on the parallel major street until you reach a street where another sign will inform you that the freeway is clear from that point north. Then proceed to the freeway

D - Remain on the parallel major street to your destination, assuming that this is possible

The results of the analyses are presented in Table 4.

These results show that the majority of the participants, when pressed for time, would prefer to remain on the parallel major street until a cross street is reached where a sign would inform them that the freeway was clear upstream from that cross street. They would then proceed to the freeway. Seventy-five percent indicated that they would take this action, in comparison to the other alternatives that were presented; one percent would choose to proceed to the freeway and enter downstream of the congested area; fourteen percent indicated a preference for using the service road to bypass the congested area; and ten percent would prefer to remain on the parallel major street to their destinations.

If the motorists are not pressed for time, the results show that they would be more inclined to remain on the parallel street until they reached their destination and less inclined to proceed to the freeway, even if they were aware that the freeway was clear of congestion.

Table 4

DRIVER RESPONSE TO REAL-TIME FREEWAY INFORMATION WHEN ON A PARALLEL MAJOR STREET

Alternative	Pressed for Time (%)	Not Pressed for Time (%)
Proceed to the freeway and enter the main lanes at the Smith Avenue on-ramp	1	3
Proceed to the freeway and use the service road to bypass the congested area	14	16
Remain on the parallel major street until you reach a street where another sign will inform them that the freeway is clear from that point north. Then proceed to the freeway	75	57
Remain on the parallel major street to your destination, assuming that this is possible	10	24

Twenty-four percent of the total sample indicated that they would remain on the major street, whereas only 57 percent indicated a preference for using the freeway when they were informed that the traffic was moving well.

The second hypothetical situation was the same as in the previous case, except it was assumed that the respondents, as drivers, had already committed themselves to the freeway service road, as shown by the X mark in Figure 3. By means of signs located in advance of the freeway entrance ramps, they would be informed of the traffic condition on the main lanes of the freeway. As before, the respondents were asked what their reactions would be when pressed for time and when not pressed for time. They were given the following alternatives:

A - Enter the main lanes of the freeway at Smith Avenue

B - Continue on the service road until you reach the entrance ramp, where another sign would indicate that the freeway main lanes were clear ahead of any heavy congestion

C - Detour over to the parallel major street and continue to your destination, assuming that this is possible

Table 5 gives the results of the respondents' reactions in this situation.

The results of the analysis show that, when pressed for time, the large majority of the respondents (86%) would remain on the service road until they reached an entrance ramp displaying a sign which indicates that the freeway main lanes are clear of any heavy congestion ahead. Thirteen percent expressed a preference to divert to the parallel major street and use this route to their destination. Only one percent indicated that they would enter the freeway.

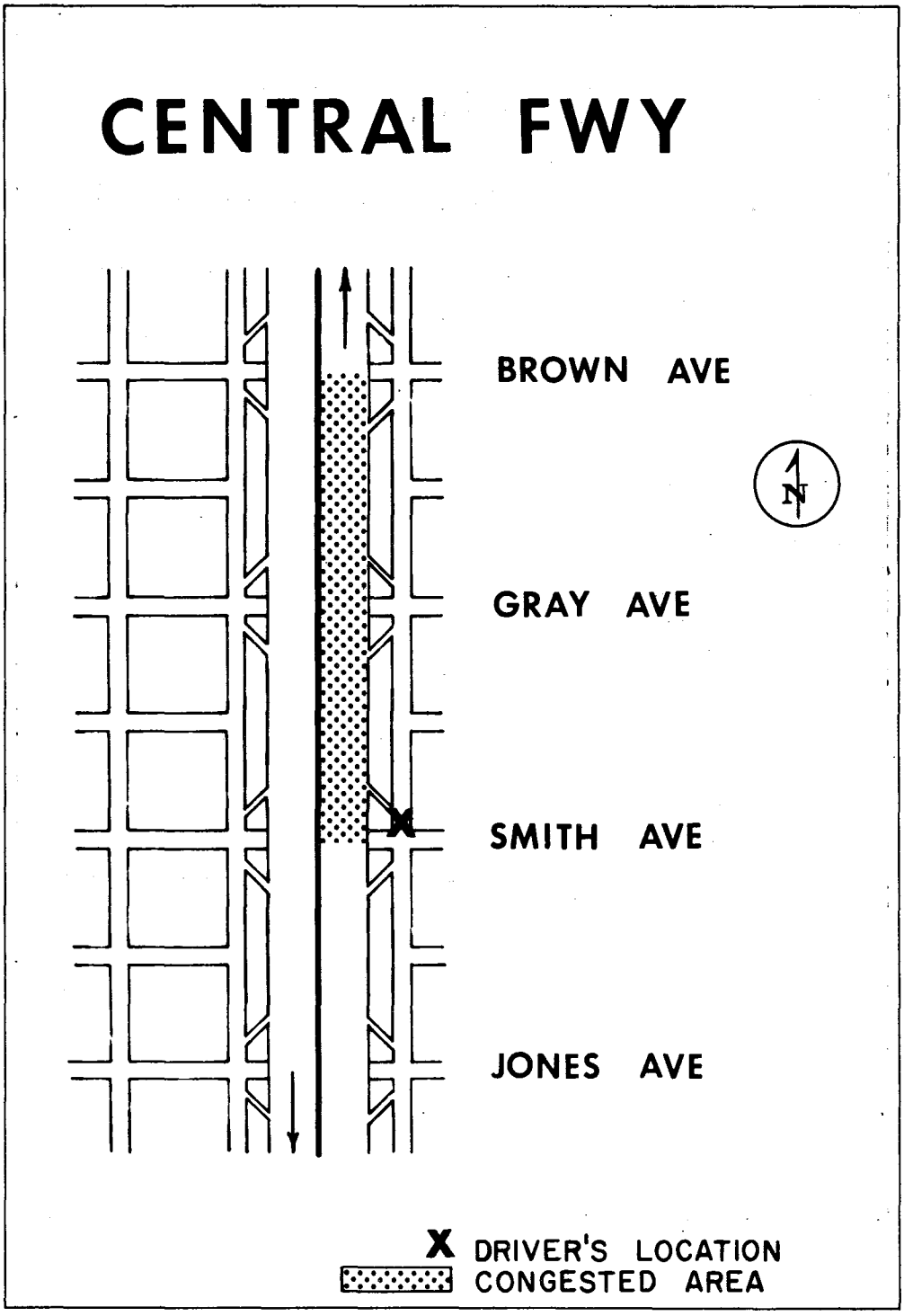


FIGURE 3—SCHEMATIC OF HYPOTHETICAL SITUATION—
DRIVER ON FRONTAGE ROAD

Table 5

DRIVER RESPONSE TO REAL-TIME INFORMATION WHEN AT THE FREEWAY ENTRANCE RAMPS

Alternative	Pressed for Time (%)	Not Pressed for Time (%)
Enter the main lanes of the freeway at Smith Avenue	1	4
Continue on the service road until you reach the entrance ramp, where another sign would indicate that the freeway main lanes were clear ahead of any heavy congestion	86	75
Detour over to the parallel major street and continue to your destination, assuming that this is possible	13	21

When time was not a consideration, the participants indicated a greater willingness to divert to the major street. A total of 21 percent indicated that they would do so, while 75 percent prefer to remain on the frontage road.

In the third situation, the participants were asked to assume that they were driving on the northbound lanes of the Central Freeway and were approaching the general area of Jones Avenue, as shown by the X mark in Figure 4. As in previous cases, the northbound lanes between Smith Avenue and Brown Avenue were heavily congested due to some incident. By means of signs located on the freeway, they would be informed of the existing traffic condition ahead. Again they were asked what their reactions would be when pressed for time and when not pressed for time. They were to select their preferences from the following alternatives:

A - Continue driving at the same speed until you actually see that the traffic condition has changed

B - Immediately reduce your speed for the anticipated change in traffic condition ahead and remain on the main lanes of the freeway

C - Exit at the next off-ramp and use the service road to bypass the congested area

D - Exit at the next off-ramp and continue to your point of destination by way of the parallel major street, assuming that this is possible

The results of the participants' responses are tabulated in Table 6.

The results show that a majority (69%) of the participants, when pressed for time, would prefer to leave the freeway and bypass the congested area using the service road. A total of 84 percent indicated that they would choose to leave the freeway to travel by way of either

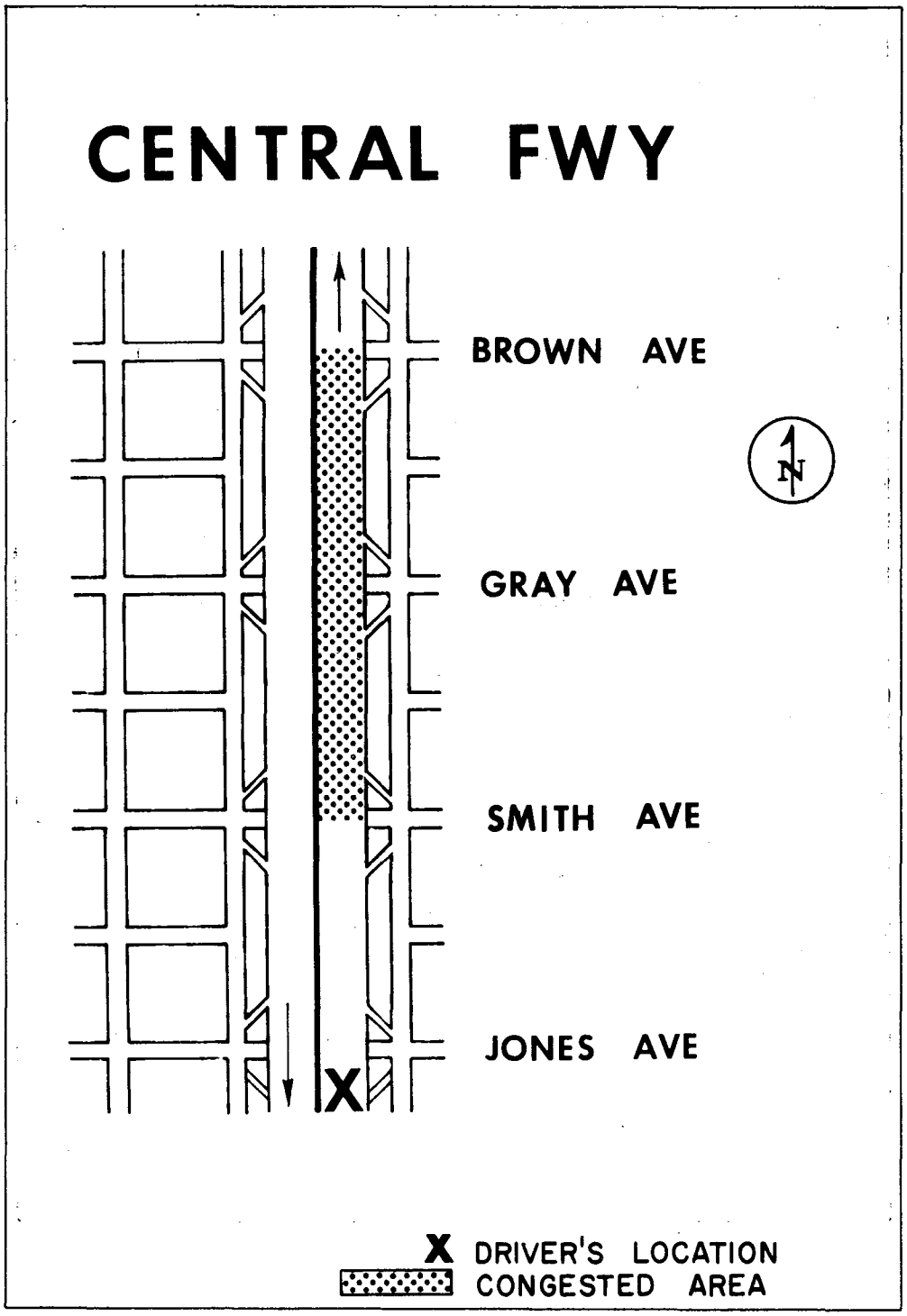


FIGURE 4—SCHEMATIC OF HYPOTHETICAL SITUATION—DRIVER ON FREEWAY

Table 6

DRIVER RESPONSE TO REAL-TIME INFORMATION WHEN ON THE FREEWAY

Alternative	Pressed for Time (%)	Not Pressed for Time (%)
Continue driving at the same speed until you actually see that the traffic condition has changed	4	11
Immediately reduce your speed for the anticipated change in traffic condition ahead and remain on the main lanes of the freeway	12	28
Exit at the next off-ramp and use the service road to bypass the congested area	69	42
Exit at the next off-ramp and continue to your point of destination by way of the parallel major street, assuming that this is possible	15	19

the frontage road or the parallel major arterial. This percentage is slightly higher than the result reported earlier, in which 75 percent indicated that they would leave the freeway and take an available major street to divert from an unusual condition on the freeway. It may be that the availability of the service road provides added confidence to the motorist of having a suitable alternate route and also of having a reasonably easy access back to the freeway.

The results also show that the participants would have a greater tendency to remain on the freeway when they were not pressed for time. A total of 61 percent indicated that they would leave the freeway to bypass the congested area when not pressed for time, in comparison to 84 percent when time was important.

In summary, the participants' reactions to these assumed hypothetical conditions indicate that the majority of the licensed drivers would use the freeway real-time information by rerouting their trips. They prefer to use either the freeway service roads or major streets, depending upon their location when informed of the condition. The majority of the drivers prefer to use the alternate route only to bypass the congested area and to return to the main lanes of the freeway as soon as possible regardless of the time of day. In addition, the motorists would be less inclined to divert once on the freeway.

Evaluation of the Type of Information By the Freeway Driver

If real-time information is to be given to the urban freeway driver, it is essential that this information be acceptable and comprehensible. Otherwise, the effort in providing such information would be completely

futile.

To evaluate driver preference for the desired types of information, the participants were asked to choose two of the following five alternatives that would be most helpful to them in describing the freeway traffic condition:

A - The degree of the congestion: Heavy, Moderate, Light

B - Location and length of a congested area

C - Travel time to various reference points ahead

D - The average travel speed obtainable between various reference points

E - Reason for the congested area, such as accident, maintenance, stalled vehicle, etc.

The results of the driver preferences are summarized in Table 7.

Two of the five alternatives are shown to be preferred by approximately 70 percent of the participants. These descriptors were the degree of congestion: heavy, moderate, light (69%) and the location and length of a congested area (71%). Information concerning the reason for the congestion, such as accident, maintenance, stalled vehicle, etc., was selected by 40 percent of the participants and was the third most preferred alternative. The travel time to various reference points ahead and the average travel speed obtainable between various reference points were the least preferred descriptors, having been selected by only 7 and 13 percent, respectively, of the participants.

The results strongly suggest that travel time and speed, both quantitative forms of information, would not be as valuable to the motorist as a system in which information may be presented in a qualitative form in terms of the degree of congestion. This is not to say

Table 7

PARTICIPANTS' RESPONSES TO PREFERENCE OF TYPE OF REAL-TIME INFORMATION

Alternative	Respondents (%)
Location and length of a congested area	71
The degree of the congestion: Heavy, Moderate, Light	69
Reason for the congested area, such as accident, maintenance, stalled vehicle, etc.	40
The average travel speed obtainable between various reference points	13
Travel time to various reference points ahead	7

that all quantitative information would be least preferred. The results only apply to the alternatives that were available to the questionnaire participants.

Evaluation of Drivers' Preferences for Modes of Communication

A portion of the questionnaire was devoted to the evaluation of drivers' preferences for modes of communication. This phase of the study has been reported in detail by Dudek and Cummings (11) in Texas Transportation Institute Research Report 139-3. A summary of the results is provided here because of their relevancy to the understanding of the total questionnaire survey.

The results of the study revealed that there is a definite preference for having real-time freeway information given to the motorists by means of commercial radio and changeable message signs, compared to a telephone or a television service. There was a division in response with respect to the selection of commercial radio or changeable message signs as the most preferred means of receiving the information. Forty-five percent chose commercial radio as the most preferred alternative, whereas 45 percent selected changeable message signs. Telephone and television modes of communication were not desired. There did not appear to be any appreciable difference between the preference for changeable message signs and the preference for commercial radio. The results of the study indicated that a combination of the two modes could result in an effective real-time freeway information system for urban areas.

Evaluation of Driver Priorities of Locations for Receiving Information

In conjunction with determining the type of information and the mode of communication for a real-time information system, it was also important to know where urban freeway drivers would like to receive this information. The participants were given the following locations and were asked to rank them in the order which would be most helpful to them in receiving the real-time information:

A. On the major streets leading to the freeways

B. At the entrance ramps to the freeways

C. At the beginning of the trips, such as at home, office, etc.

D. On the freeway

Table 8 shows the ranking distributions of each location.

The results of the analysis indicate that motorists prefer to receive information about the freeway traffic condition before they enter the freeway and at locations where decisions can be made with respect to the selection of an alternate route. Forty-two percent of the participants selected the beginning of the trip to be the most desirable location in relation to the other alternatives, 34 percent chose to receive information on the major street, 16 percent at the entrance ramps, and 8 percent on the freeway. The lowest rankings were "on the freeway" and "at the beginning of the trip".

The data were analyzed further to determine whether there was consistency in the rankings between the participants. Kendall's Coefficient of Concordance (12) was computed. The coefficient detects the consistency (or lack of consistency) in the ranking of ordinal data.

Table 8

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME INFORMATION

Location	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking Points*	Standard Deviation
On The Freeway	8	14	34	44	1.9	0.9
On The Major Street	34	39	18	9	3.0	0.9
At The Entrance Ramps	16	36	41	7	2.7	0.8
At The Beginning of Trip	42	11	7	40	2.6	1.3

*Based on assigning 4 points to each first choice, 3 points to each second choice, 2 points to each third choice, and 1 point to each fourth choice. Maximum Possible Mean = 4.0; Minimum Possible Mean =

Kendall's Coefficient of Concordance, W = 0.1332
Chi Square, χ^2 = 181.4**
d.f. = 3

The significance of the coefficient was then tested, using the Chi Square statistic. The analysis is presented in Table C-1 in Appendix C and the results are reproduced in Table 8. The test is not designed to reveal the degree of preference but does yield an ordering effect of the respondents.

The results of the analysis in Table C-1 revealed that Kendall's coefficient was equal to 0.1332. In addition, the computed Chi Square value of 181.4 was highly significant at the .01 level, indicating that there was consistency in the ranking between respondents. The order of preference was as follows:

1. On the major street
2. At the entrance ramp
3. At the beginning of the trip
4. On the freeway

The dichotomy of the results with respect to receiving information at the beginning of the trip is quite interesting, in that 42 percent ranked this alternative as the most preferred, whereas 40 percent ranked it as the least preferred. These results seem to indicate that approximately half of the freeway drivers prefer to know the freeway traffic condition before beginning their trip, while the other half find it unnecessary. Analyses of these two subgroups were therefore made and have been included in an earlier report (11). Data of the subgroups that selected either radio or signs as the preferred mode of communication were also analyzed to establish whether there were any relationships between the selection of location and the mode of

communication.

In summary, there appeared to be a relationship between the selection of modes and of location. The participants who preferred to receive freeway traffic information at the beginning of their trips ranked radio as their first choice of communication. Those who considered receiving information at the beginning of the trip of least value to them selected signs as their first choice of communication.

The participants who selected radio as their preferred mode indicated that they considered information at the beginning of the trip and on the major streets to be of greatest value. The preference for the two location alternatives was considered to be equal. These individuals also felt that information on the freeway was of least importance in relation to the other alternatives.

The analysis also revealed that those who chose signs as the preferred mode of communication placed a high emphasis for information on the major streets and at the entrance ramps. Information at the beginning of the trip and information on the freeway were considered equal in importance but were least preferred.

Evaluation of Driver Comprehension of and Preferences for Visual Displays

Basic Visual Displays - If a freeway information system is to be effective, it is important that the messages be comprehensible. Changeable message signs show promising possibilities for communicating with the motorist in real-time (1). Consequently, it was desirable to evaluate some basic visual displays.

Several designs have been experimented with in Detroit, Chicago, and elsewhere, all of which have been evaluated independently. No data were available to compare the signs so that conclusions could be reached as to the best features of each design. Therefore, a slide presentation to be coordinated with the questionnaire was designed to evaluate visual displays. This portion of the survey was designated Part III.

Four basic designs were developed and used for evaluating comprehension of and preferences for visual displays:

Design 1 - A sign containing words and color indications to describe the traffic condition

Design 2 - A sign portraying only color indications to reflect the traffic conditions

Design 3 - A sign depicting a diagram of the area, using illuminated color symbol indications to show the traffic conditions

Design 4 - A sign illustrating a diagram of the area, giving travel speeds between reference points

There was one exception to this pattern which will be discussed later.

All of the signs were similarly designed with white letters on a green background and a red indication to describe congested conditions and a green indication to specify normal conditions. The diagrams, when used, were illustrated in white. Travel speeds were depicted using white numerals on a black background.

The designs were such that only one basic difference existed between Design 1 and 2, between 2 and 3, and between 3 and 4, respectively. Consequently, the participants' choice of, for example,

Design 1 over 2 would indicate a preference for the use of word messages to describe the traffic condition. Diagrams to outline the schematic of the freeway and street system were used as an added device for helping the motorist in orientating himself on the street system. Analysis of the basic differences will help to determine the characteristics of the final design that are desirable.

Through the use of a slide presentation, the participants were confronted with three separate hypothetical situations as follows:

Case I - On the Major Street

Case II - On the Frontage Road

Case III - On the Freeway

The reader is referred to pages 16-23 and Figures 2, 3, and 4 for a detailed description of these hypothetical situations.

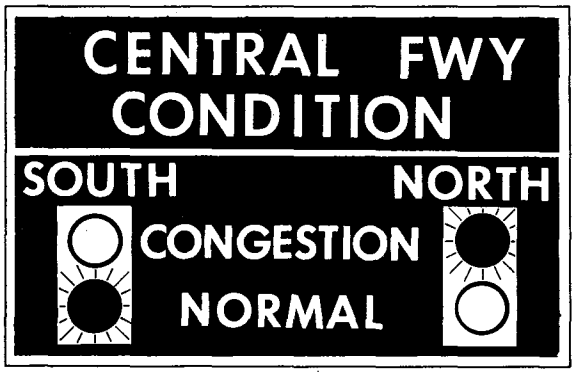
Each of the above three cases was individually presented to the participants. They were asked to rank each sign independently, giving it a rating from a low of 1 to a high of 5, according to how well it described the traffic condition to them as motorists. After each sign was individually rated for a particular case, the participants were shown a slide containing all four designs and were asked to rank these according to their preferences. Although the basic designs were similar for each of the three cases, the signs were shown in random order for each of the cases so as to eliminate any bias that may have occurred from the order of presentation.

The purpose of the individual rating tests was to determine whether any of the basic designs were acceptable as candidates. For example, if all designs received very low ratings, one could assume that none of the alternatives was acceptable to the participants. If some received high ratings while others received low ratings, one could evaluate the basic differences between the signs that were most desirable to the participants.

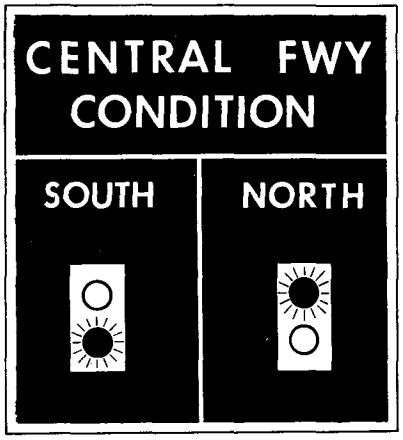
Ranking, on the other hand, was used as a test to determine the relative desirability of the various designs in cases of equal ratings. For example, if two designs were given equal ratings as to their abilities to communicate the appropriate messages, then the rankings would produce the relative desirability between them. Mean rankings were computed by assigning 4 points for each first choice, 3 points for each second choice, 2 points for each third choice and 1 point for each last choice.

When ratings are given to individual items, the question arises as to what constitutes "good". A rational decision had to be made prior to analyzing the data. With respect to the signs that were given ratings by the participants, using a scale which ranged from 1 to 5, the authors reasoned that a rating of 3.5 or higher would constitute an acceptable design, and a rating of 4.5 or higher would constitute a highly desirable sign. Using these criteria, the acceptability of a particular design could be evaluated.

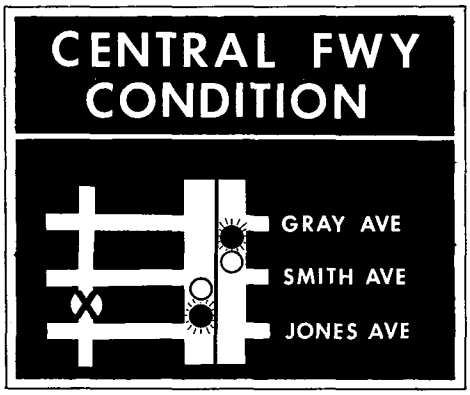
The sign designs that were evaluated for use on the major street (Case I) are shown in Figure 5. The designs of the visual displays for use at the entrance ramps (Case II) and on the freeway (Case III)



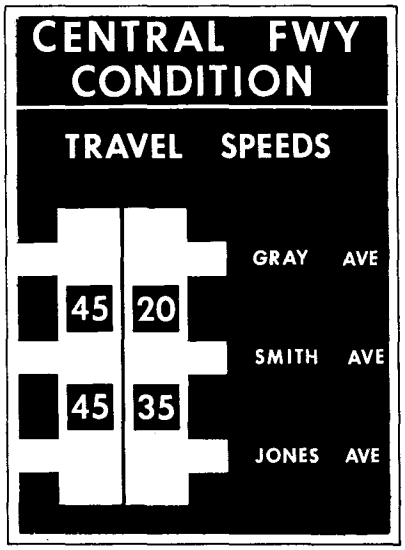
DESIGN 1



DESIGN 2

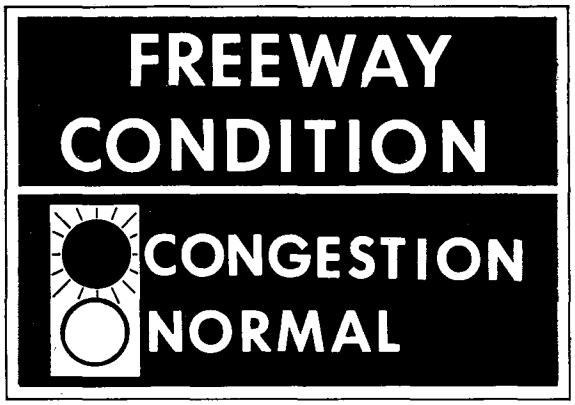


DESIGN 3

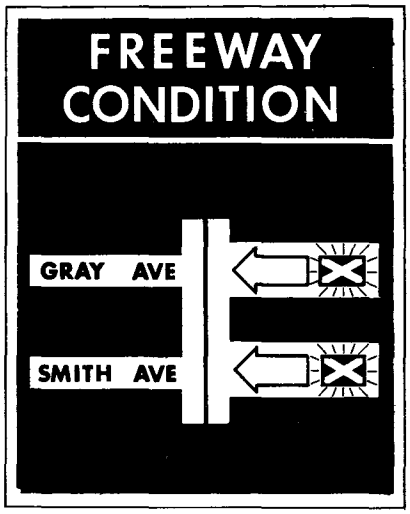


DESIGN 4

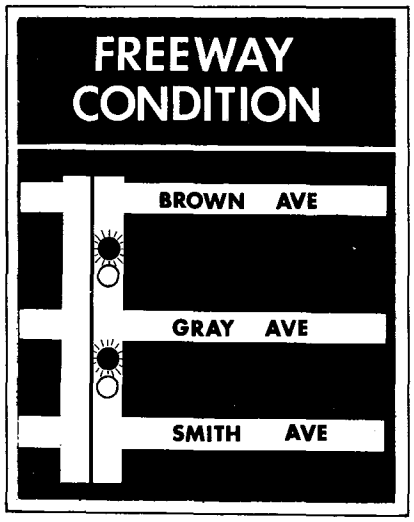
FIGURE 5—SIGN DESIGN ALTERNATIVES FOR DISPLAY ON MAJOR STREETS — CASE I



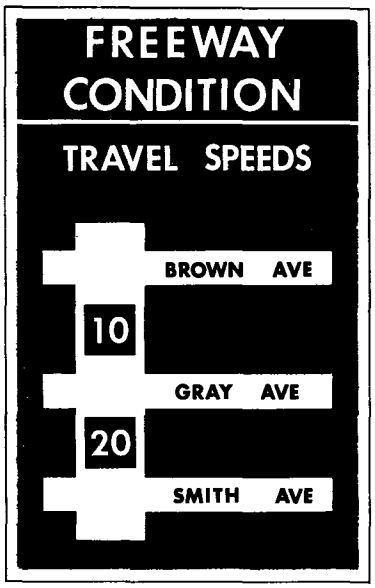
DESIGN 1



DESIGN 2

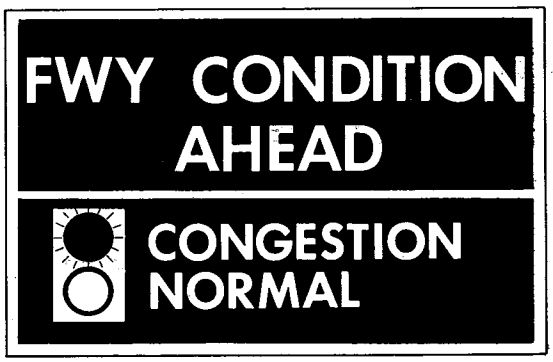


DESIGN 3

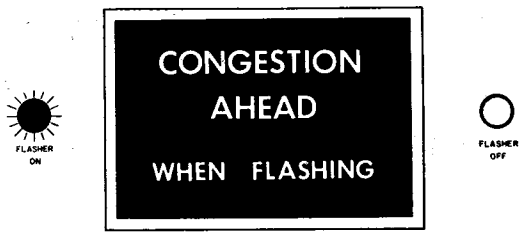


DESIGN 4

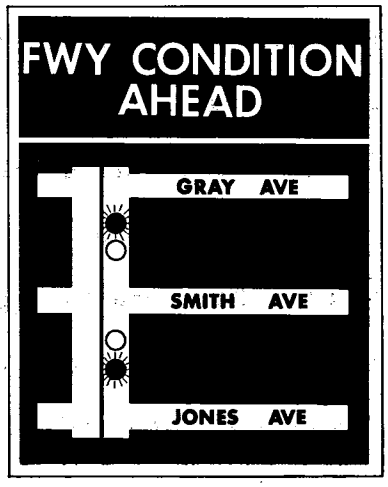
FIGURE 6—SIGN DESIGN ALTERNATIVES FOR DISPLAY AT THE ENTRANCE RAMPS—CASE II



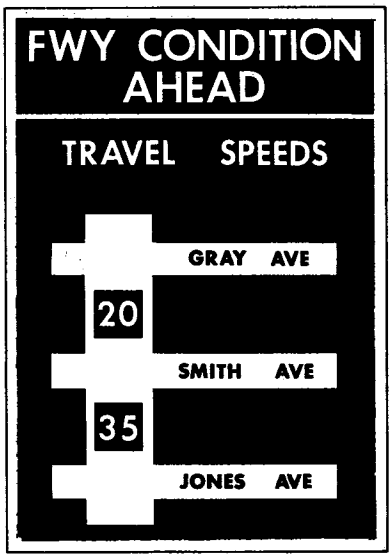
DESIGN 1



DESIGN 2



DESIGN 3



DESIGN 4

FIGURE 7—SIGN DESIGN ALTERNATIVES FOR DISPLAY ON THE FREEWAY—CASE III

are shown in Figures 6 and 7, respectively.

It should be noted that one of the basic designs for Case II was slightly different from the pattern listed on page 34. The second design incorporated both color indications to reflect the traffic conditions, as well as a diagram of the area to assist the motorist in orientating himself to the facility. In Case I and Case III, the diagram was not used for this design.

Displays on the Major Street (Case I) - The results of the ratings of each sign and the rankings of the signs for Case I are presented in Figures 8 and 9, respectively. Frequency distributions for the ratings and rankings are shown in Figures 10 and 11, respectively.

The results clearly show that the basic designs which were simple in nature were preferred over those which displayed a diagram of the areas. The design which contained words and color indications (Design 1) and the design which used only color indications (Design 2) to describe the freeway traffic condition were rated relatively high, whereas the designs which had a diagram of the area were rated relatively low. The mean ratings for Designs 1 and 2 were 4.0 and 3.5, respectively, whereas the mean rating for Design 3, which had color indications on a diagram of the area, was 2.5 and for Design 4, which displayed speed on a diagram, was 2.4. No defined conclusion can be drawn between Designs 3 and 4 since the means of their ratings and rankings are approximately the same. On the basis of the pre-established criteria, only Designs 1 and 2 were above the acceptable mean limit.

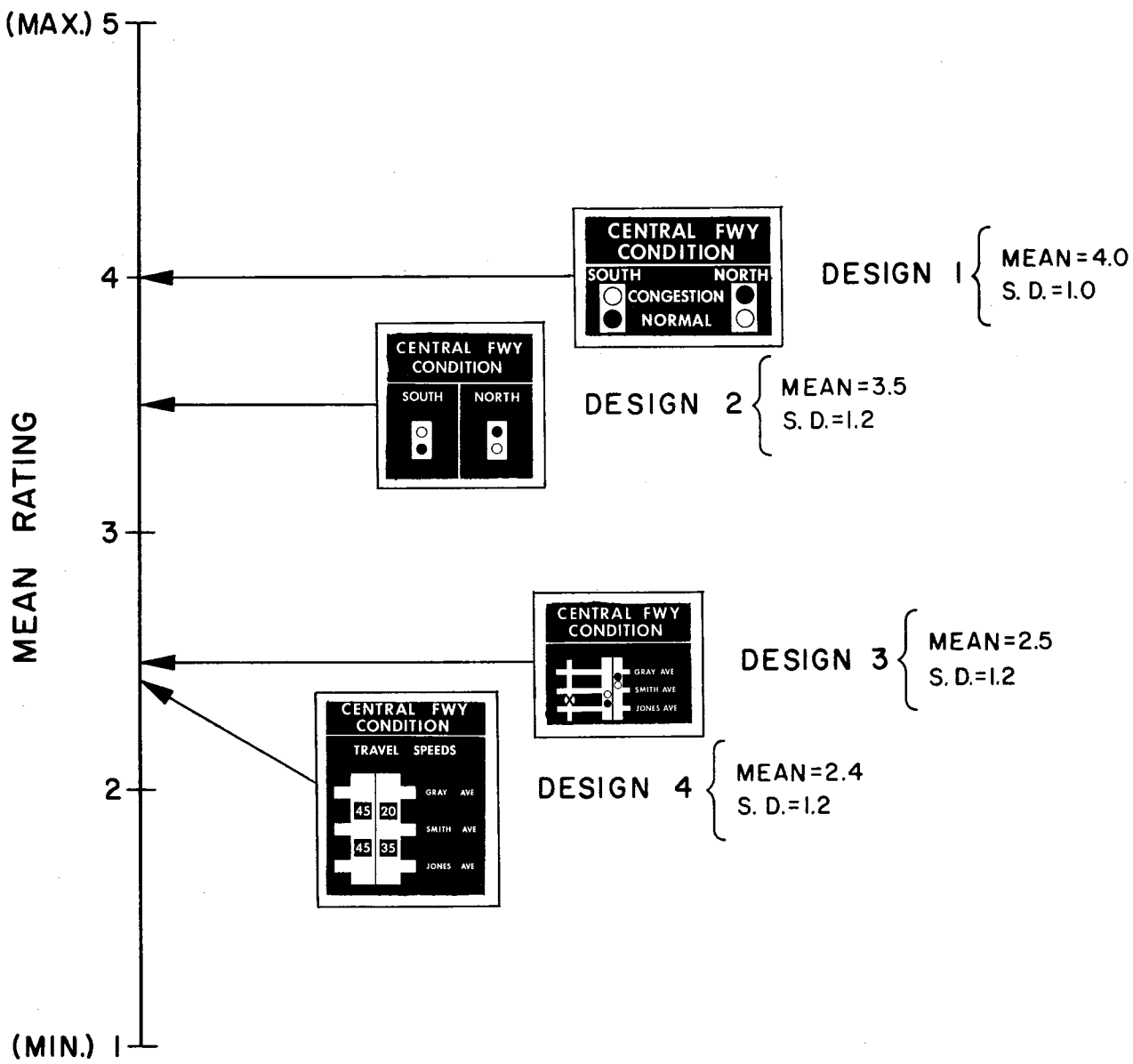
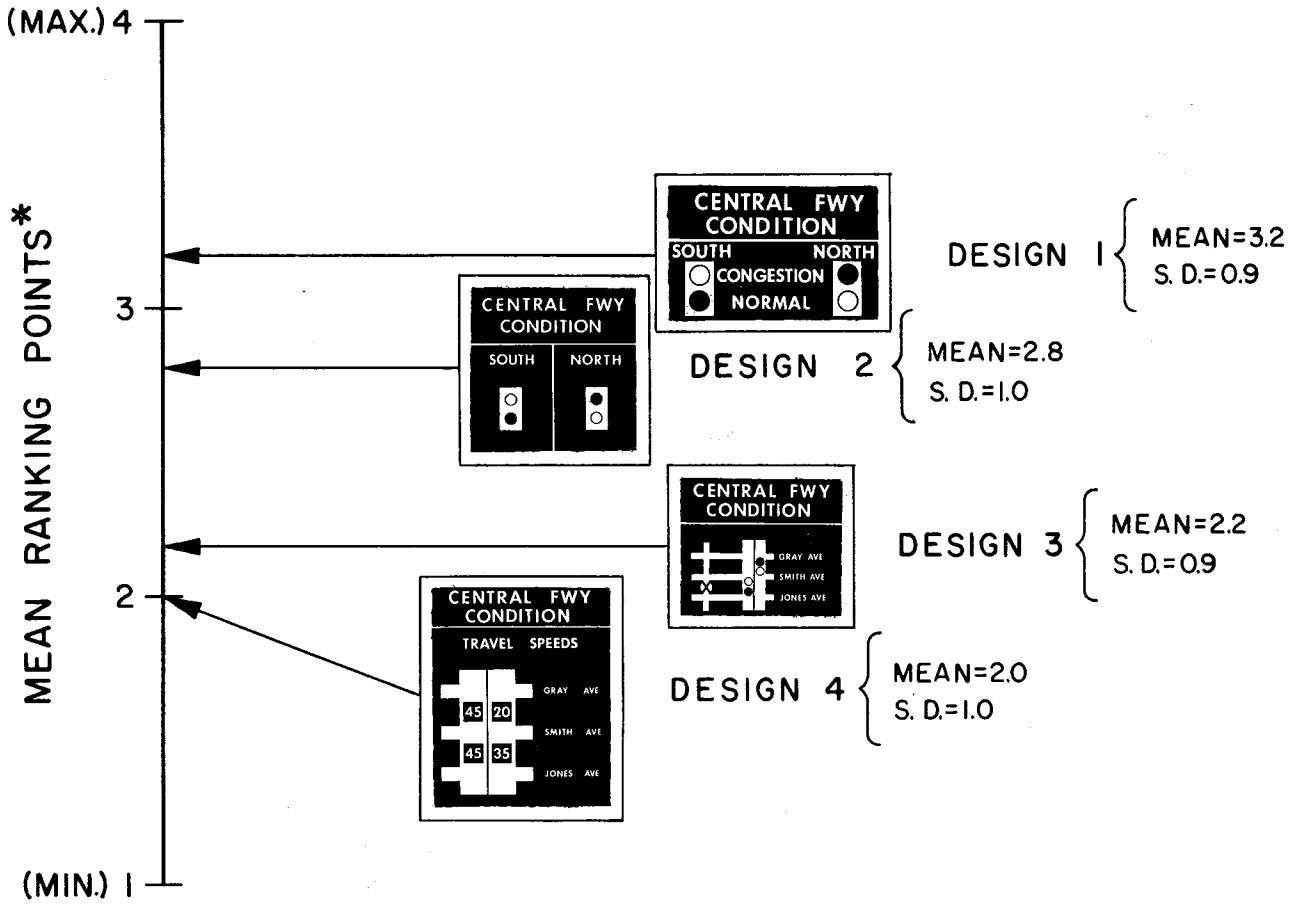


FIGURE 8 — RATINGS OF SIGN DESIGN ALTERNATIVES FOR DISPLAY ON MAJOR STREETS — CASE I



*BASED ON ASSIGNING 4 POINTS TO EACH FIRST CHOICE, 3 POINTS TO EACH SECOND CHOICE, 2 POINTS TO EACH THIRD CHOICE, AND 1 POINT TO EACH FOURTH CHOICE. MAXIMUM POSSIBLE MEAN=4.0; MINIMUM POSSIBLE MEAN=1.0

FIGURE 9 —RANKINGS OF SIGN DESIGN ALTERNATIVES FOR DISPLAY ON MAJOR STREETS— CASE I

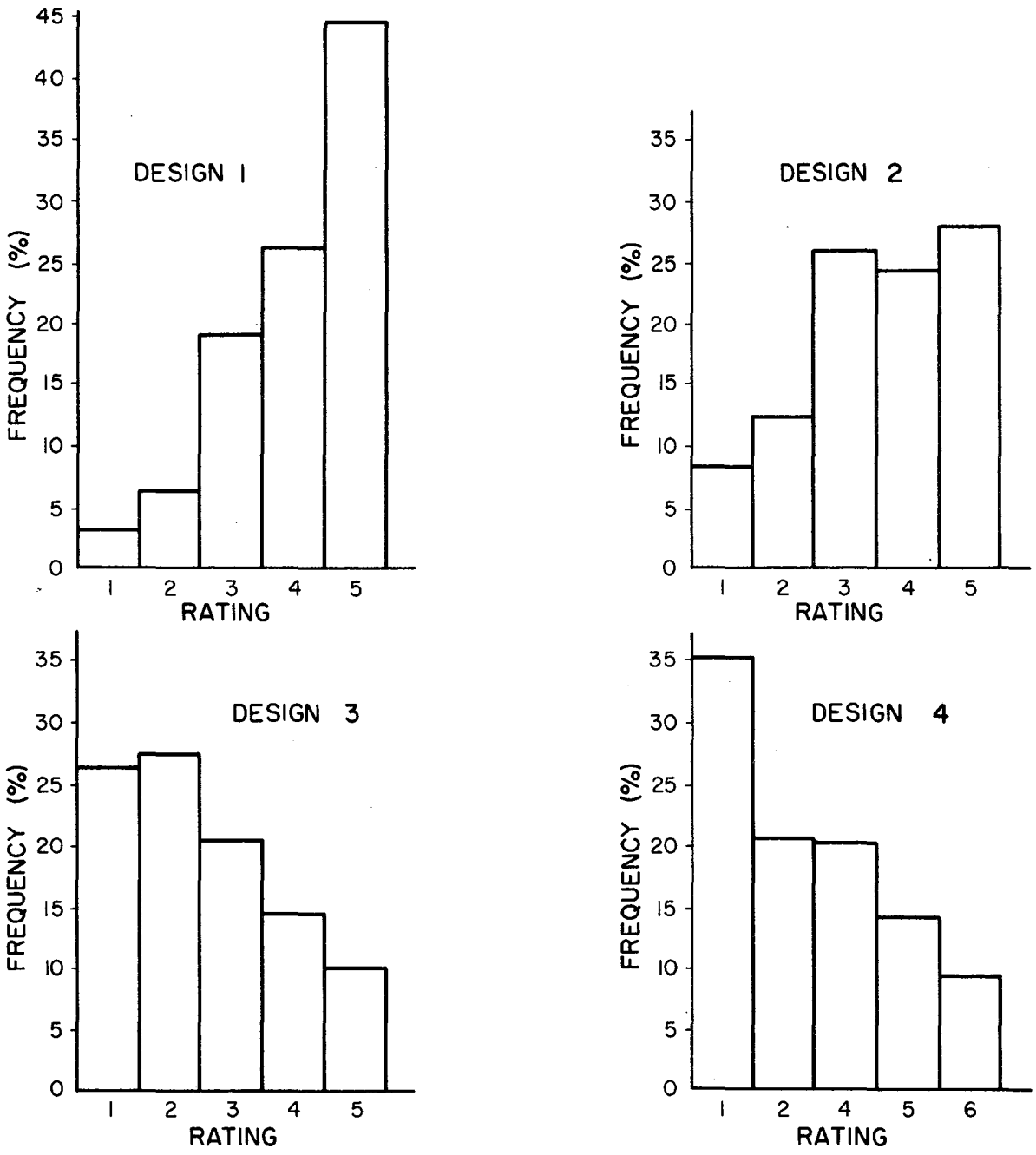


FIGURE 10 - FREQUENCY DISTRIBUTIONS FOR RATINGS OF SIGN DESIGN ALTERNATIVES - CASE I

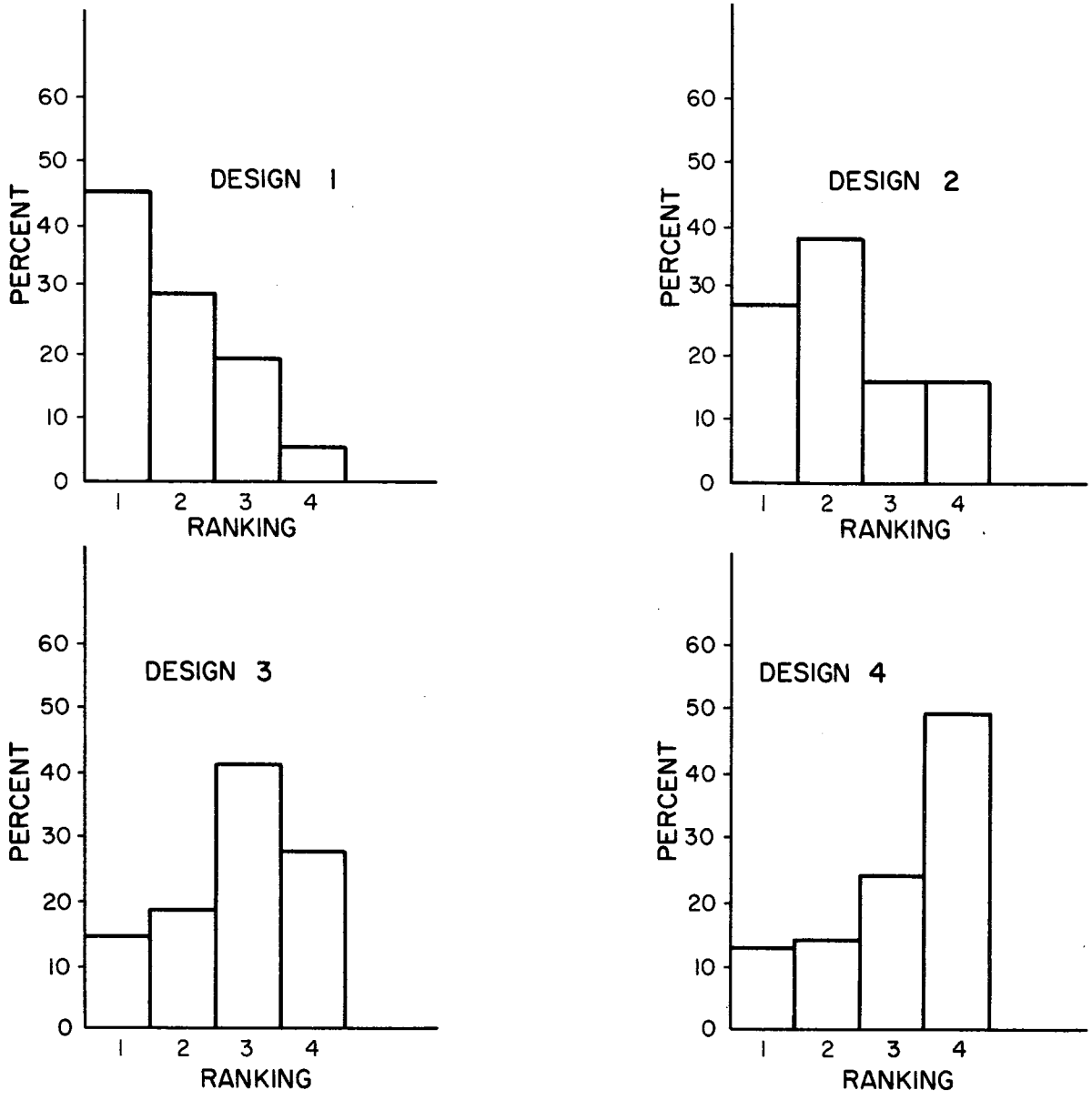


FIGURE 11-FREQUENCY DISTRIBUTIONS FOR RANKINGS OF SIGN DESIGN ALTERNATIVES - CASE I

Kendall's Coefficient of Concordance and the Chi Square test of significance were also computed to determine whether there had been consistency in the manner in which the participants ranked the designs. The computations are presented in Table C-2 of Appendix C. The results of the test revealed that coefficient, W, was 0.1841, and the Chi Square value of 224.3 was highly significant at the .01 level. This meant that the respondents had ranked the signs consistently. The preference for the signs was in the following order:

1. Design 1
2. Design 2
3. Design 3
4. Design 4

The results suggest that word messages describing the freeway conditions would be slightly more desirable than a design which was void of qualitative messages. They also reinforce the results of the ratings of each sign. The participants preferred the simple designs over the designs which displayed a diagram of the area.

Displays At The Entrance Ramps (Case II) - The results of the analysis of the visual displays for use at the entrance ramps are presented in Figures 12, 13, 14 and 15.

The results again clearly show that the design which was simple in nature was preferred over the designs which contained a diagram of the area. The mean rating for the design using a color signal indication and word messages (Design 1) had a mean rating of 3.9, whereas Designs 2, 3 and 4, all of which contained a diagram of the area, had mean

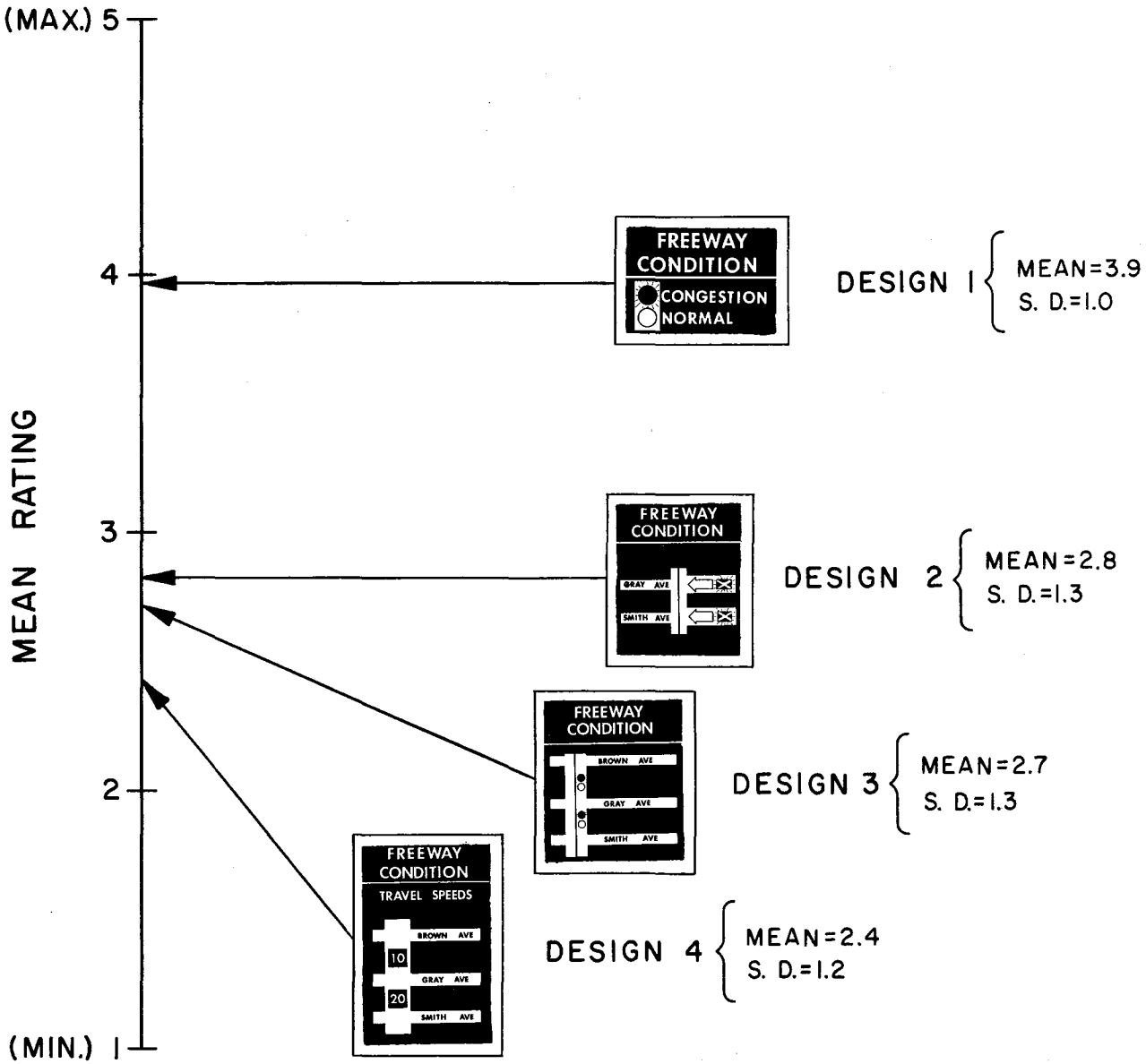
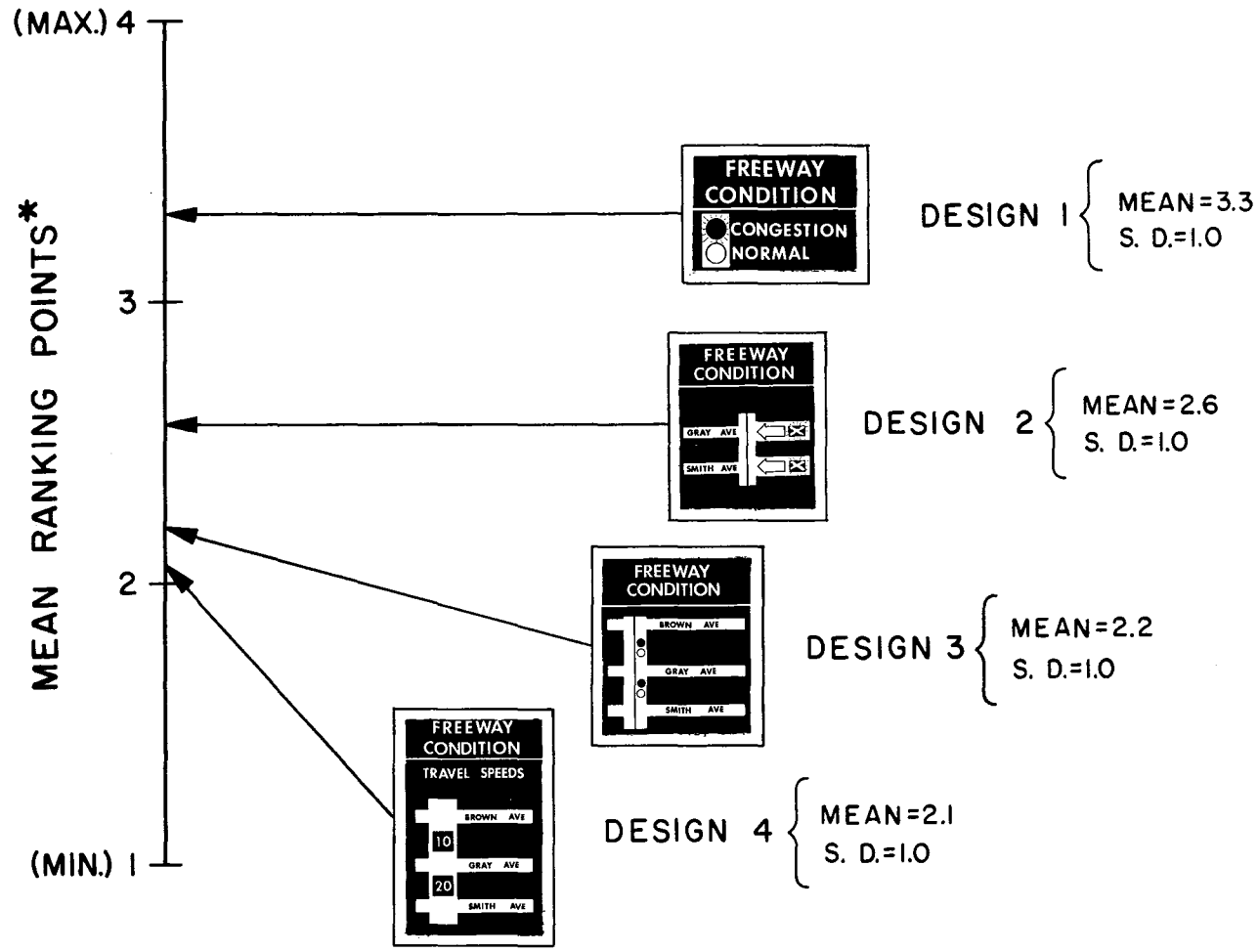


FIGURE 12–RATINGS OF SIGN DESIGN ALTERNATIVES FOR DISPLAY AT ENTRANCE RAMPS— CASE II



*BASED ON ASSIGNING 4 POINTS TO EACH FIRST CHOICE, 3 POINTS TO EACH SECOND CHOICE, 2 POINTS TO EACH THIRD CHOICE, AND 1 POINT TO EACH FOURTH CHOICE. MAXIMUM POSSIBLE MEAN=4.0; MINIMUM POSSIBLE MEAN=1.0

FIGURE 13—RANKINGS OF SIGN DESIGN ALTERNATIVES FOR DISPLAY AT ENTRANCE RAMPS—CASE II

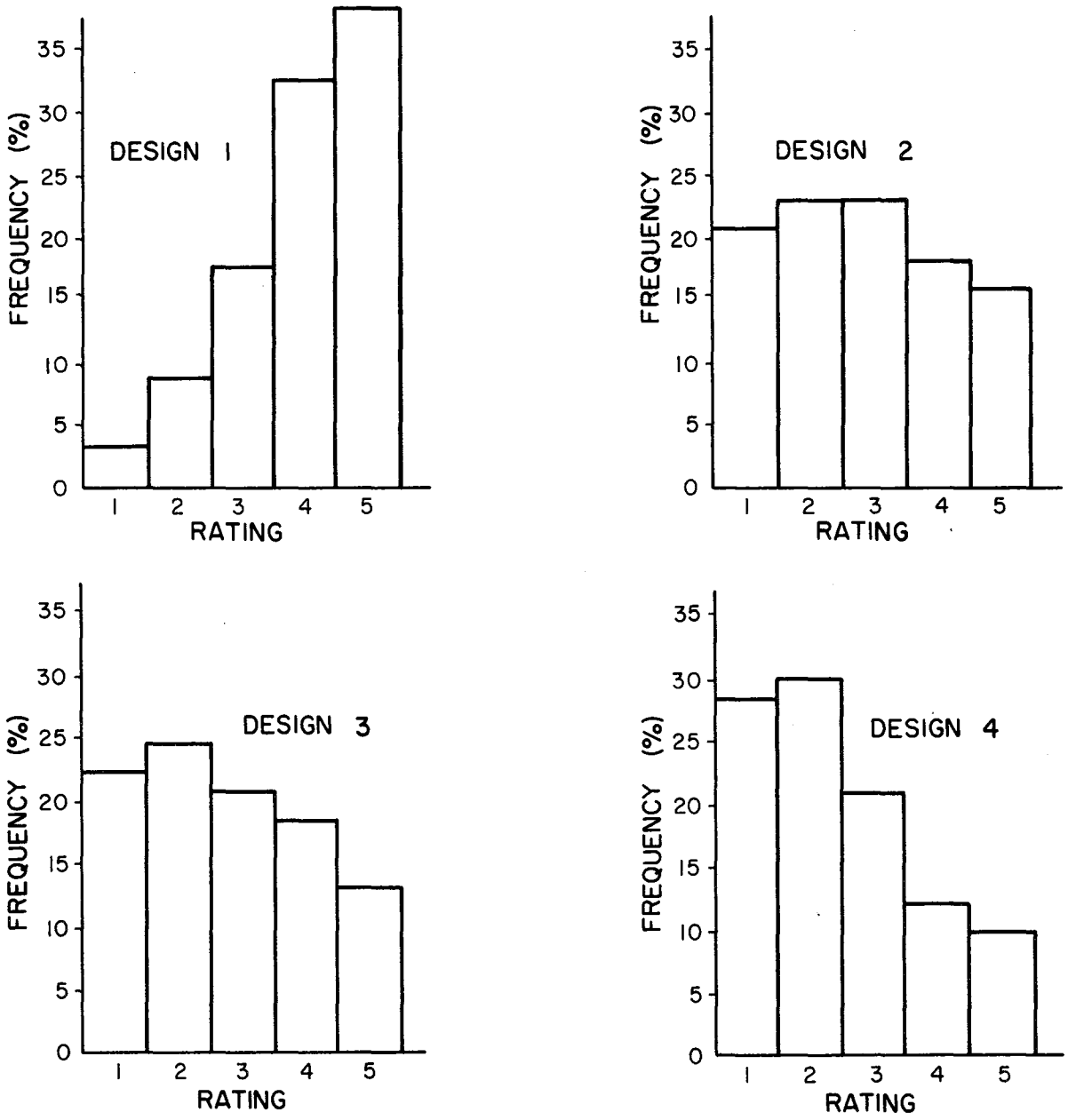


FIGURE 14-FREQUENCY DISTRIBUTIONS FOR RATINGS OF SIGN DESIGN ALTERNATIVES - CASE II

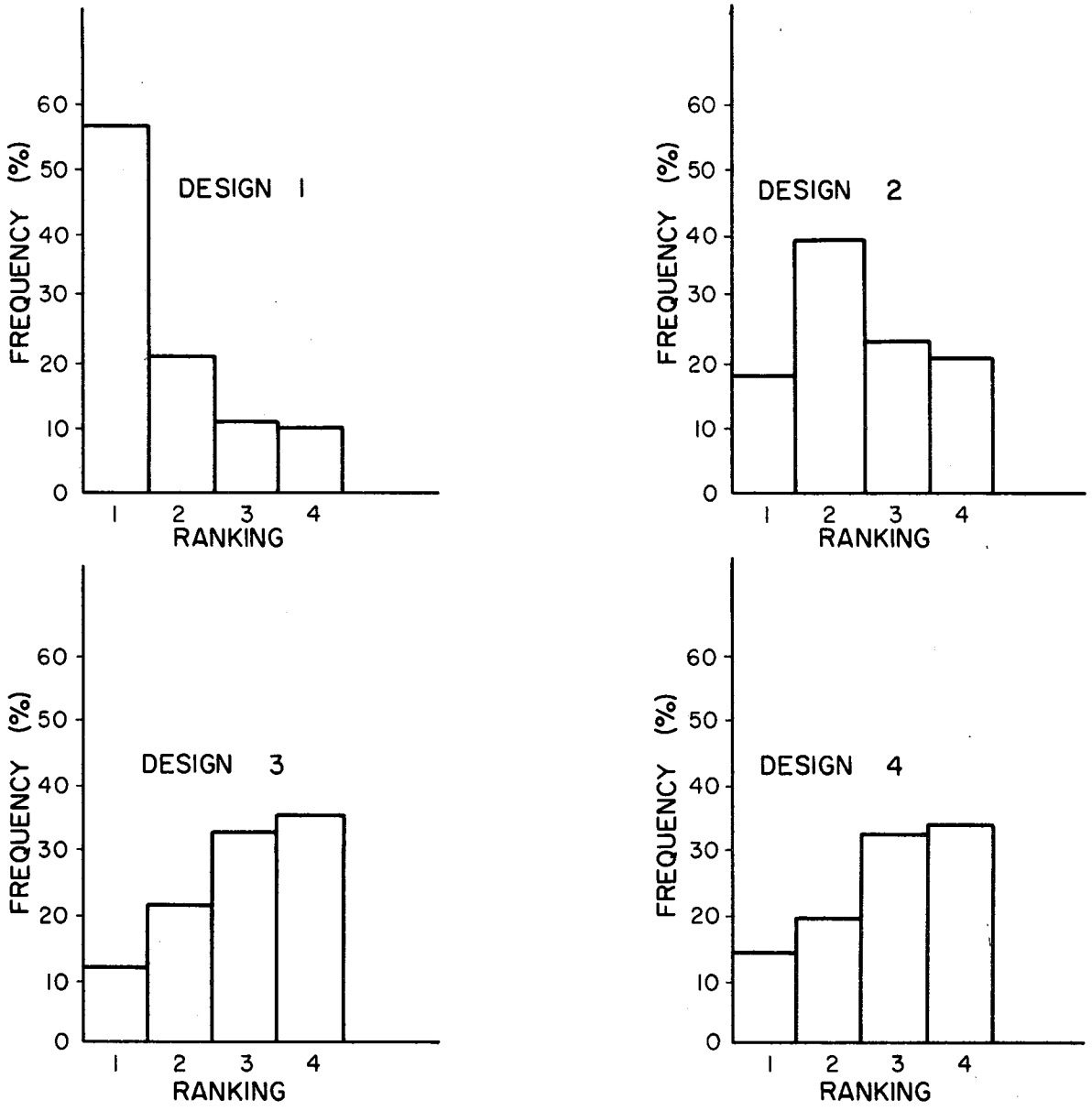


FIGURE 15 — FREQUENCY DISTRIBUTIONS FOR RANKINGS OF SIGN DESIGN ALTERNATIVES - CASE II

ratings of 2.8, 2.7, and 2.4, respectively. Only Design 1 was above the acceptable mean limit of 3.5. The rankings of the alternate signs were consistent with the ratings of the individual signs. The mean ranking for Design 1 was 3.3, while the mean rankings for Designs 2, 3 and 4 were 2.6, 2.1 and 2.2, respectively.

The results of Kendall's Coefficient of Concordance for the consistency of ranking these four signs are tabulated in Table C-3 in Appendix C. The results again establish that the participants were consistent in the manner in which they ranked the signs. Kendall's coefficient, W, was computed as 0.1697, and the Chi Square test was highly significant at the .01 level. The tabulated order of ranking for Case II was as follows:

1. Design 1
2. Design 2
3. Design 3
4. Design 4

Displays On The Freeway (Case III) - The results of the ratings and the rankings of the sign display alternatives for use on the freeway are shown in Figures 16 and 17. Frequency distributions of the participants' responses to the ratings and rankings are presented in Figures 18 and 19, respectively.

The results again show a preference for simplicity in design. Designs 1 and 2 had mean ratings of 4.1 and 3.6, respectively, both of which were above the acceptable mean limit. The two designs which incorporated a diagram of the freeway and streets had mean ratings of 2.8

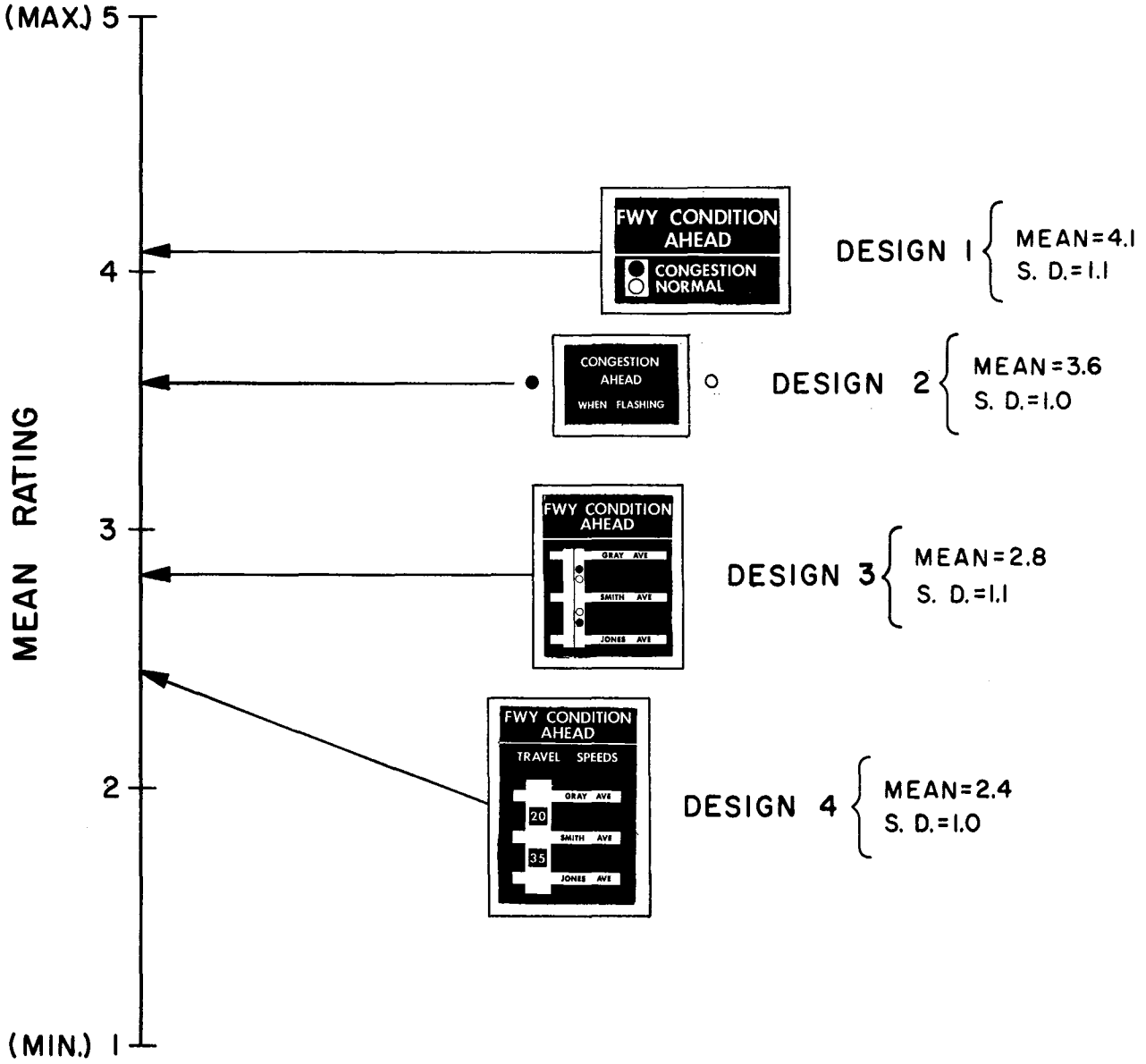


FIGURE 16—RATINGS OF SIGN DESIGN ALTERNATIVES FOR DISPLAY ON THE FREEWAY—CASE III

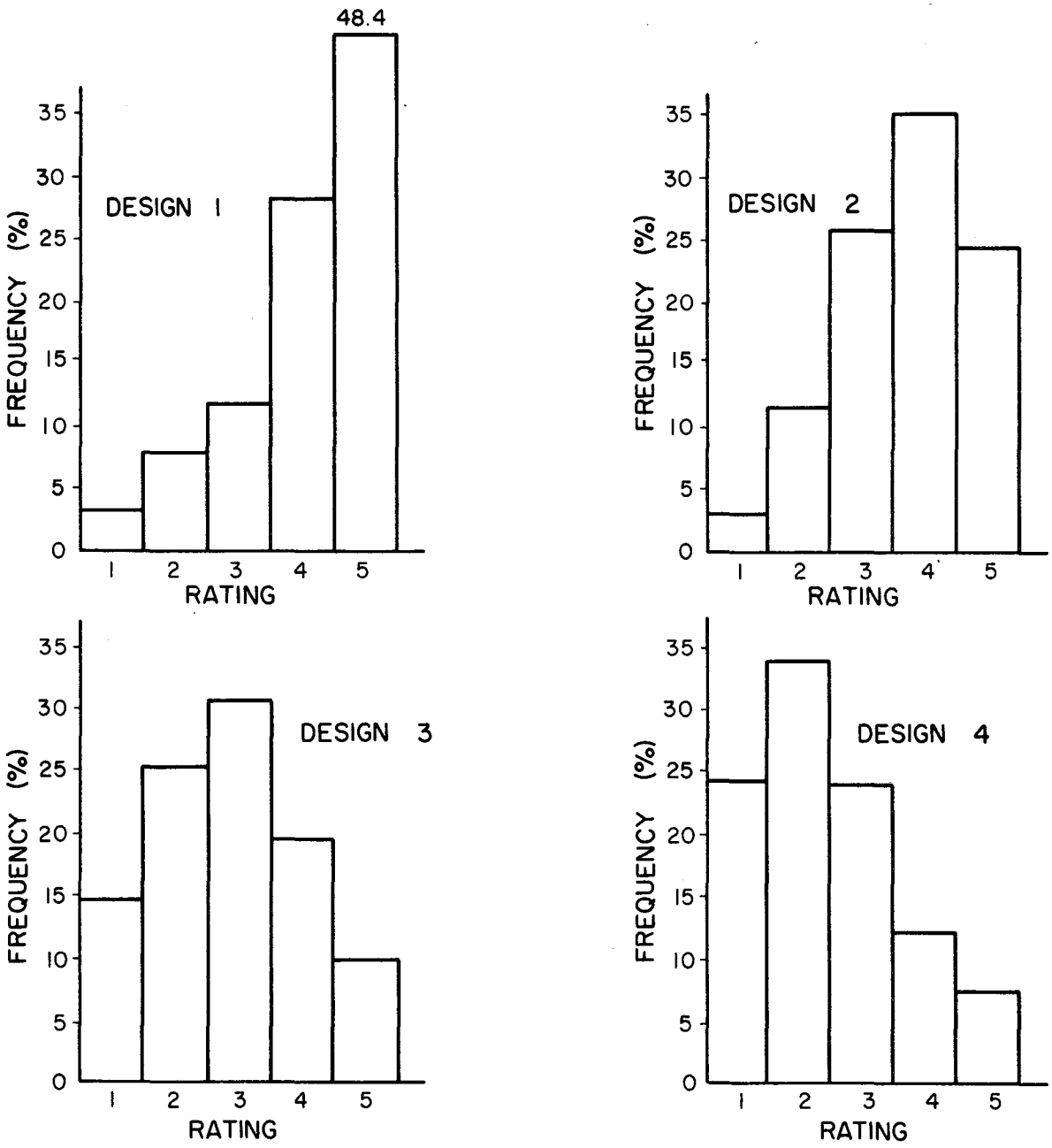


FIGURE 18 – FREQUENCY DISTRIBUTIONS FOR RATINGS OF SIGN DESIGN ALTERNATIVES – CASE III

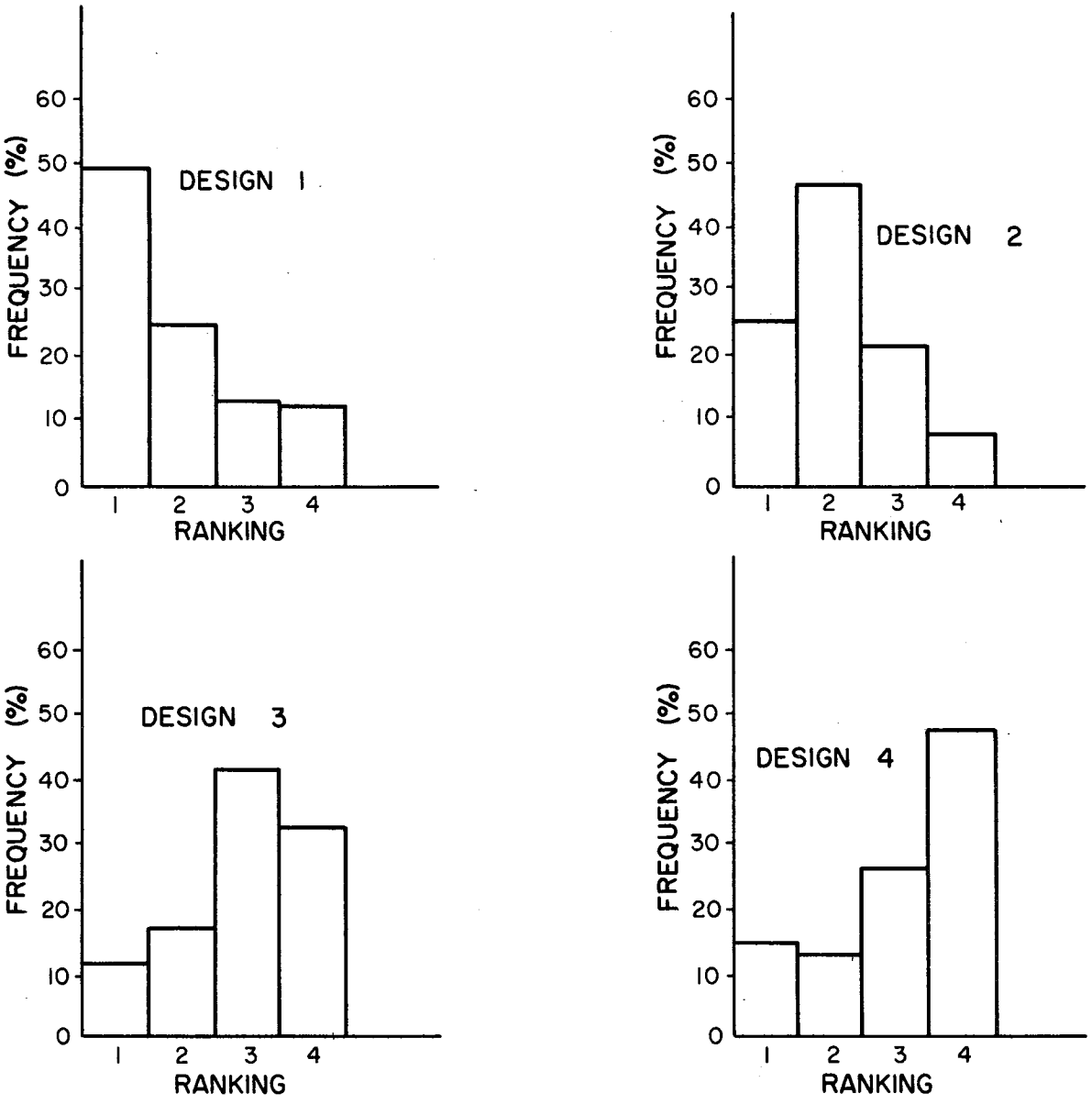


FIGURE 19 — FREQUENCY DISTRIBUTIONS FOR RANKINGS OF SIGN DESIGN ALTERNATIVES - CASE III

and 2.4. The results of the rankings again show Design 1 to be the preferred alternative followed by Design 2, Design 3 and Design 4 in that order. Kendall's coefficient test is presented in Table C-4 of Appendix C. The results reveal a consistent pattern in the ranking of the four signs. The ranking of the designs was in the following order:

1. Design 1
2. Design 2
3. Design 3
4. Design 4

Summary of Ratings and Rankings of Visual Displays - To gain a better understanding of the results concerning the design alternatives for a total system, the mean ratings and rankings for Cases I, II and III are shown in Table 9. The comparison is made for the purpose of showing the consistency of the four basic designs. There was definite consistency in the ratings and rankings for all three cases.

The results of the ratings and rankings of the four basic designs of signs indicate the preference for simplicity of design for a sign that would inform the motorist of the freeway traffic conditions. Although it had been conjectured that diagrams providing the driver with an orientation to the freeway and streets would be a valuable asset, the results of the study indicate that this type of display is the least preferred of all the alternatives. Though the measureable differences between the quantitative term travel speed indication and the color indication were small, it is of interest to note that the travel speed displays were rated and ranked last in all three cases.

Table 9

COMPARISON OF THE PARTICIPANTS' EVALUATION OF THE VISUAL DISPLAYS FOR ALL THREE ASSUMED CONDITIONS

	CASE I		CASE II		CASE III	
Designs	Mean Rating *	Mean Ranking **	Mean Rating *	Mean Ranking **	Mean Rating *	Mean Ranking **
Design 1	4.0	3.2	3.9	3.3	4.1	3.2
Design 2	3.5	2.8	3.8	2.6	3.6	2.9
Design 3	2.5	2.2	2.7	2.1	2.8	2.1
Design 4	2.4	2.0	2.4	2.2	2.4	2.0

*Mean determined by assigning 1 point for rating of 1(Low), 2 points for rating of 2, 3 points for rating of 3, 4 points to rating of 4, and 5 points to rating of 5(High)

**Mean determined by assigning 4 points to each first choice, 3 points to each second choice, 2 points to each third choice and 1 point to each fourth choice.

Word Messages - Several alternatives are available for providing freeway traffic information to the driver that describe the freeway traffic conditions, regardless of whether the information is visual or audio. One alternative is to present the information using qualitative messages such as "congestion," "heavy congestion," etc.

To evaluate driver comprehension of and preference for qualitative word messages, the participants were asked to select from several alternatives a word message that would be most meaningful to them in describing a situation in which an unusual disturbance on the freeway causes the traffic to move at a slower rate of speed than usual. The participants were asked to make one selection, assuming the incident occurred during the peak period, and another selection assuming the incident occurred during the off-peak period. The following alternatives were presented to the participants:

1. Congestion
2. Extra Delay
3. Freeway Breakdown
4. Heavy Congestion
5. Heavy Traffic
6. Jammed Freeway
7. Slow Traffic
8. Stop and Go Traffic
9. Traffic Jam

The participants were also asked to select the message which would be most meaningful to them in describing the freeway traffic flow that they would normally expect during the peak periods and also during the off-peak periods. The alternatives were as follows:

1. Clear
2. Free Flowing Traffic
3. No Delay
4. Normal
5. Normal Traffic
6. Uncongested

These questions were asked during Part II of the questionnaire. In Part III of the questionnaire, the slide presentation was made in order to evaluate visual displays. These two parts of the questionnaire were alternated in the order they were presented to different groups of participants, to identify any bias introduced from questions in one part of the survey influencing the answers to those in the other part. It was speculated, therefore, that the audiences responding to Part III prior to Part II may have been influenced in their selections of the word messages by those messages that were introduced in the slide presentation. Consequently, an analysis was also made to check for this possible influence.

The results of the analysis of the qualitative word messages are shown in Tables 10 and 11. The results of the group analysis indicate that the visual displays presented to the participants in Part III of the questionnaire influenced, in part, their choices of words. The words "normal" and "congestion" to describe traffic conditions on the freeway were used throughout Part III of the questionnaire. Only 10 percent of the participants who answered Part II before answering Part III selected "congestion" as the most preferred word to describe freeway traffic when an unusual condition exists during the peak period; however, 23 percent of those who answered Part II after viewing the slides chose the word "congestion". This constitutes an increase of 11 percentage

Table 10

PREFERENCES OF WORDS FOR DESCRIBING UNUSUAL TRAFFIC CONDITIONS

Words	Peak Periods			Off-Peak Periods		
	All Resp. (%)	Group 1* (%)	Group 2** (%)	All Resp. (%)	Group 1* (%)	Group 2** (%)
CONGESTION	17	10	23	28	15	40
EXTRA DELAY	5	7	3	5	5	5
FREEWAY BREAKDOWN	3	3	3	3	3	3
HEAVY CONGESTION	30	26	35	12	10	9
HEAVY TRAFFIC	7	9	4	9	10	9
JAMMED FREEWAY	12	16	8	5	8	2
SLOW TRAFFIC	4	6	2	24	29	20
STOP & GO TRAFFIC	12	11	12	9	11	7
TRAFFIC JAM	10	11	9	5	7	3

*Participants who answered Part II before answering Part III of the questionnaire.

**Participants who answered Part III before answering Part II of the questionnaire.

Table 11

PREFERENCES OF WORDS FOR DESCRIBING USUAL TRAFFIC CONDITIONS

	Peak Periods			Off-Peak Periods		
Words	All Resp. (%)	Group 1* (%)	Group 2** (%)	All Resp. (%)	Group 1* (%)	Group 2** (%)
CLEAR	6	6	5	13	13	12
FREE FLOWING TRAFFIC	19	27	12	20	25	15
NO DELAY	3	4	3	4	5	5
NORMAL	40	24	54	36	24	47
NORMAL TRAFFIC	29	33	24	22	26	18
UNCONGESTED	3	5	2	5	6	4

*Participants who answered Part II before answering Part III of the questionnaire.

**Participants who answered Part III before answering Part II of the questionnaire.

points. Likewise, only 15 percent of the former group selected "congestion" as the preferred word for describing the condition during the off-peak periods; forty percent of those participants who viewed the slides before responding to the questions in Part II selected the word "congestion." It appears that the use of this word in the slide presentation did indeed influence its selection later in the survey. Similar results were noticed with the selection of words to describe usual conditions on the freeway. There was an increase of from 24 to 54 percent of those individuals who selected "normal" as the best descriptor during the peak periods and an increase of from 24 to 47 percent of those who chose the word for off-peak periods. Consequently, a reasonable approach would be to base decisions, with respect to preference of messages, only on the group that responded to Part II of the questionnaire before Part III (Group #1).

Considering Group #1 only, therefore, the results show that "heavy congestion" seemed to be slightly preferred as a qualitative descriptor of freeway traffic when an unusual condition exists during the peak periods. However, this descriptor was favored by only 26 percent of the respondents. For the off-peak periods, the descriptor "slow traffic" received 29 percent of the votes, while each of the others received 15 percent or less. It is difficult to draw any definite conclusions from this analysis because no descriptor received a majority of the votes, either for the peak period or for the off-peak period. The large number of alternatives that were available offered too many possibilities for the survey participants. Perhaps a more restricted

and better classification of the alternatives for these conditions may have provided more meaningful results.

There is a trend, however, that is indicated by the data. The fact that different descriptors were preferred (even though not a majority) for each period might suggest that it is desirable to use words during the peak periods to describe abnormal traffic conditions different from those used during the off-peak.

A result of the analysis of Group #1, to describe usual conditions encountered during the peak and off-peak periods, revealed that three descriptors were prominent (receiving 25 percent or more of the votes). These were "free flowing traffic," "normal," and "normal traffic." The predominant descriptors were the same for both the peak and off-peak periods. The latter two descriptors, in reality, are so similar that they may be considered as being the same. Consequently, the descriptor "normal" or "normal traffic" may be considered as the most preferred, having been selected by at least 50 percent of the participants. However, the results do not seem to indicate a need to distinguish, in qualitative words, conditions that the motorists usually encounter during the peak period as compared to the off-peak period.

Special Displays - In Part II of the questionnaire, specific questions were asked the participants in order to evaluate driver preferences for the types of messages that would be most useful. A portion of Part III was designed to obtain inputs regarding some of the special features of visual displays, while at the same time to verify some of the responses obtained in Part II.

In one group of questions, the participants were asked to make comparisons among three pairs of signs. Only one different feature existed between each pair. The alternatives that were compared are shown in Figure 20. In each of the three comparisons, the participants were asked to indicate their selection from the following choices:

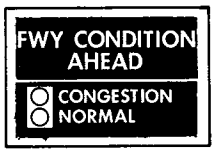
1. Alternative A is best
2. Alternative B is best
3. Alternatives A & B are equally good

Test I was a comparison to determine whether the participants would like to receive information regarding the location of congestion. Test II was used to establish whether the color of the lamps in the visual display would affect the choice of signs. This in essence was one means of measuring the desire for distinct colors to indicate varying degrees of traffic operation. Test III was intended to measure the desirability of the motorists for knowing the nature of the incident that causes the congestion.

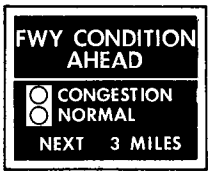
The results reveal that 87 percent of all respondents preferred information regarding the location of the congested area, in addition to the qualitative description of the traffic condition. The results also show that 7 percent of the respondents were indifferent about receiving the added information pertaining to the location of the congestion.

A comparison of the color of the signals in Test II showed that a majority of the respondents preferred the red and green signals, in contrast to all yellow. A total of 69 percent indicated their preferences for the red and green combinations, 21 percent preferred all yellow, and 10 percent were indifferent. This result suggests the desirability of color to distinguish the different traffic conditions on

TEST I

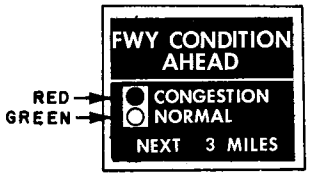


ALTERNATIVE A

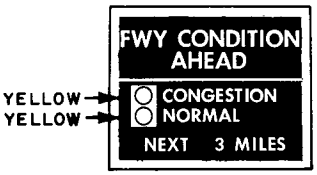


ALTERNATIVE B

TEST II

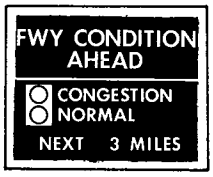


ALTERNATIVE A

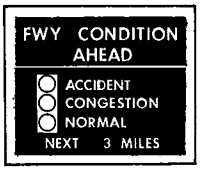


ALTERNATIVE B

TEST III



ALTERNATIVE A



ALTERNATIVE B

FIGURE 20—SPECIAL FEATURE ALTERNATIVES FOR VISUAL DISPLAY

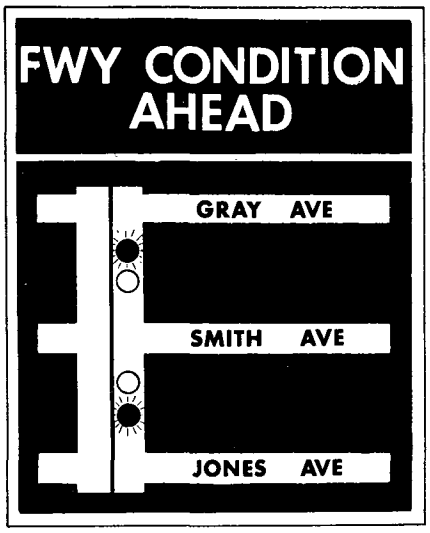
the freeway.

An analysis of the desirability for knowing the occurrence of an incident in Test III indicated that only slightly more than half of the respondents desired to know that an accident has occurred, in addition to the freeway traffic condition and the length of the congested area. Fifty-seven percent of the respondents favored the display which indicated the occurrence of an accident, 26 percent did not desire this added information, and 17 percent were indifferent.

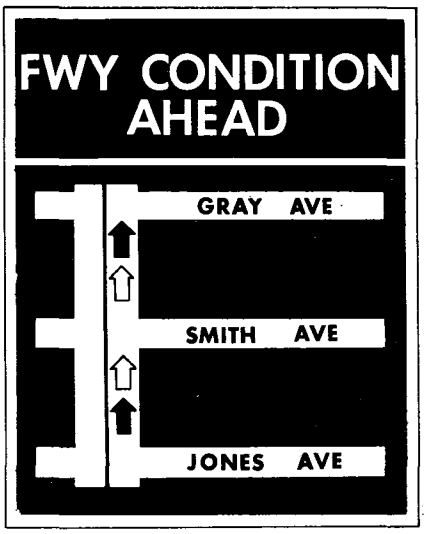
These results are very consistent with those discussed earlier on pages 26-28 pertaining to the type of information desired by the motorists. As previously noted, the respondents placed the highest priorities on knowledge of the following: 1) the degree of congestion and 2) the location of the congestion. Knowledge of the reason for the congested area was preferred by 40 percent of the respondents.

It was also of interest to determine the desirability of certain types of symbols which could be used on visual displays. Three alternatives, as illustrated in Figure 21, were presented to the participants for ranking. The results of this analysis are shown in Table 12.

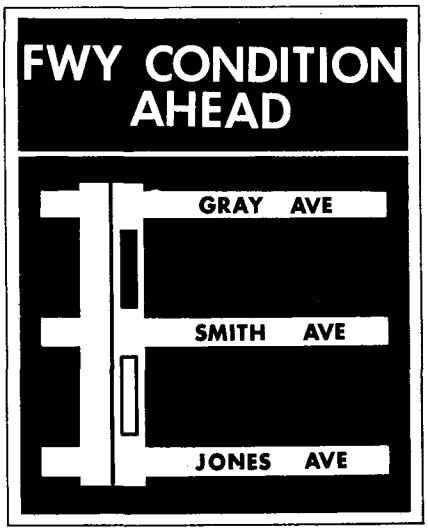
Kendall's Coefficient of Concordance was again employed to determine whether there was a definite degree and consistency of ranking. The results of the analysis are tabulated in Table C-5 of Appendix C. The coefficient was computed to be 0.0113, and the test of significance revealed a Chi Square value of 7.60. The results were not significant at the .01 level. The interpretation of the results is that there was no meaningful pattern or consistency in the ranking of the three symbols.



ALTERNATIVE A



ALTERNATIVE B



ALTERNATIVE C

FIGURE 21 – SPECIAL SYMBOL ALTERNATIVES FOR VISUAL DISPLAY

Table 12

DRIVER PREFERENCES OF SYMBOLS FOR VISUAL DISPLAYS

Symbol	1st. Choice (%)	2nd. Choice (%)	3rd. Choice (%)	Average Ranking Points *	Standard Deviation
Circle	52	25	23	2.3	0.8
Arrow	27	53	20	2.2	0.7
Bar	21	22	57	1.7	0.8

*Based on assigning 3 points for each 1st choice, 2 points for each 2nd choice and 3 points for each 3rd choice. Maximum Possible Mean = 3.0; Minimum Possible Mean =1.0

Kendall's Coefficient of Concordance, = 0.0113
Chi Square χ^2= 7.60**
d.f. = 2

Therefore, there was no reason to believe that an order of preference existed among the symbols.

The participants were asked for their opinions concerning the possible color combinations of a sign giving information about the freeway traffic condition. They were presented the following choices:

1. White letters on a green background, as used for guide signs.
2. Black letters on a yellow background, as used for warning signs.
3. A new color combination to distinguish these signs from all other signs.
4. No preference

Table 13 shows the results. These results indicate that the drivers prefer a unique device that clearly distinguishes real-time freeway information from other types of freeway signing.

Subgroup Analysis

There had been some speculation that the responses of those participants who indicated that they did not use the freeway for their work trips might differ from those who did. Similarly, the preference to drive the city streets may have influenced the response by some participants. Consequently, the data were analyzed to test any differences in response of these subgroups.

The results revealed that the subgroup analysis would not lead to any conclusions that differ materially from the analysis of the entire group. The supporting data are presented in tables and figures of Appendix D.

Table 13

PREFERENCES OF COLORS FOR THE SIGNS

Choices	Respondents (%)
White Letters on Green Background	22
Black Letters on Yellow Background	9
New Color Combination	62
No Preference	7

SUMMARY OF FINDINGS

This research was directed toward the development of functional requirements for a real-time freeway communication system for urban areas. Based on the analysis of a questionnaire survey administered to 505 drivers, the following findings may be drawn from the report:

1. Urban freeway drivers desire additional traffic information which is not currently provided by passive signing. They also considered real-time traffic information as having considerable potential in meeting their overall information needs.

2. Freeway motorists would react to real-time information by rerouting to the nearest and best available alternate route. The majority prefer to use the alternate route only to by-pass congested areas on the freeway. Most freeway drivers prefer to return to the freeway.

3. Motorists are more inclined to divert to an alternate route before they reach the freeway than once on the freeway.

4. The two information descriptors most preferred were 1) the location and length of the congested area and 2) the degree of congestion. Seventy-one percent of the respondents selected the former descriptor, and 69 percent selected the latter. The

reason for the congested area, such as an accident, maintenance, stalled vehicle, etc. was preferred by 40 percent of the motorists. The quantitative descriptors of travel time and travel speed were the least preferred, having been selected by only 7 and 13 percent, respectively.

5. Commercial radio and changeable message signs were preferred over telephone and television services. There did not appear to be any appreciable difference between the preference for changeable message signs and the preference for radio (See reference 11).

6. Motorists prefer to receive information about freeway traffic conditions before they enter the freeway. The following constitutes the ranking of preferred locations for communications.

    1. On the major street
    2. At the entrance ramp
    3. At the beginning of trip
    4. On the freeway

7. Motorists prefer a real-time information sign display that is simple in nature. Simple type displays were consistently preferred over designs containing a diagram that provided the motorists with an orientation of the freeway and streets. The following designs were consistently rated high:

    1. Design 1 - A sign containing words and color indications to describe the traffic conditions

2. Design 2 - A sign portraying only color indications to reflect the traffic conditions

The following designs were consistently rated low:

1. Design 3 - A sign depicting a diagram of the area, using illuminated color symbol indications to show the traffic conditions

2. Design 4 - A sign illustrating a diagram of the area, giving travel speeds between reference points

8. It was not possible to draw any definite conclusions from the analysis performed on word descriptors that describe freeway traffic conditions. However, the data suggest that the use of different word descriptors is desirable to distinguish abnormal conditions during the peak from those during the off-peak.

9. The descriptors "normal or normal traffic" were considered as the most preferred descriptors of usual conditions encountered during the off-peak and peak periods. Fifty percent of the motorists selected one of these two descriptors.

10. Motorists prefer a unique design that distinguishes real-time visual displays from other types of freeway signing.

11. Motorists prefer unique design features, such as the use of color, on visual displays to distinguish between usual and abnormal conditions.

12. There was no reason to believe that there was a preference for any of the following symbols which could be used on a real-time visual display: circle, arrow, or bar.

13. In general, the difference in response was insignificant between the group commuting to work via the freeway and those individuals who do not use the facility.

14. In general, there was no significant difference in response between the individuals who prefer to drive the city streets and those who prefer the freeway.

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APPENDIX - A

QUESTIONNAIRE

PART I.

Information Section:

1. Sex: _____Male _____Female

2. Age: _____

3. Occupation: _____

4. Education Completed:

   _____a. Grade School

   _____b. High School

   _____c. Business College or Trade School

   _____d. Two years of College

   _____e. Senior College

5. How much Driver Education Training have you had?

   _____a. None

   _____b. Classroom

   _____c. Behind Wheel

   _____d. Classroom & Behind Wheel

6. How many years have you been driving?_____

7. Approximately how many miles do you drive per year?

   _____a. Less than 8,000

   _____b. 8,000 to 12,000

   _____c. 12,000 to 18,000

   _____d. 18,000 to 30,000

   _____e. Greater than 30,000

8. Approximately how much experience do you have in driving on freeways in cities with a population over 100,000 such as Amarillo, Waco, Corpus Christi, Dallas or Houston?

_____a. None

_____b. Less than 6 Mo.

_____c. 6 Mo. to 1 Yr.

_____d. Greater than 1 Yr.

9. Approximately how many times a week do you use a freeway in a large city? (EXAMPLE: To and from work 5 days a week would be 10 trips).

_____a. None

_____b. 1 to 5

_____c. 6 to 10

_____d. 11 to 20

_____e. Greater than 20

10. Do you normally use a freeway to go to and from work?

Yes_____ No_____

11. Which of the following do you normally prefer to travel on within a large city, if you have a choice?

_____a. Freeway

_____b. City Street

PLEASE STOP AT THIS POINT

PART II.

1. (a) How many times in a week do you normally use a freeway during the MORNING RUSH HOUR - between 6:30 A.M. and 8:30 A.M. - Monday thru Friday?

_____a. 0

_____b. 1 to 4

_____c. 5 or more

(b) Would you use the freeway more often during the MORNING RUSH HOUR if you knew the traffic condition on the freeway was favorable?

Yes _____No_____

(c) If you have answered 1(b) with a "No", please indicate below the reason why.

_____a. Normally do not have to drive during this time

_____b. Normally do not have to use the freeway more than already indicated above during this time

_____c. There is no freeway available

_____d. Prefer to use major streets instead of a freeway

_____e. Others_____

_____

_____

2. (a) How many times in a week do you normally use a freeway during the AFTERNOON RUSH HOUR - between 4:00 P.M. and 6:00 P.M.- Monday thru Friday?

_____a. 0

_____b. 1 to 4

_____c. 5 or more

(b) Would you use the freeway more often during the AFTERNOON RUSH HOUR if you knew that the traffic condition on the freeway was favorable?

Yes_____No_____

(c) If you have answered 2(b) with a "No", please indicate below the reason why.

_____a. Normally do not have to drive during this time

_____b. Normally do not have to use the freeway more than already indicated above during this time

_____c. There is no freeway available

_____d. Prefer to use major streets instead of a freeway

_____e. Others_____

_____

_____

3. Assume that you have to make trips during the MORNING and AFTERNOON RUSH HOURS and there is a major street that you can take instead of a freeway.

   (a) If you were informed before entering the freeway that the freeway traffic was moving slower than usual for that time of the day, would you take the major street?

   Yes_____No_____

   (b) Now assume that you were already traveling on the freeway in a free flowing area, and were then informed that the freeway traffic ahead of you was moving slower than usual for that time of the day, would you exit and seek the major street?

   Yes_____No_____

4. Suppose you were driving toward the freeway, or you are already traveling on it, during those hours that are NOT considered RUSH HOURS. If you were given reliable information that the traffic condition ahead on the freeway was moving slower than usual for that time of the day, would you take an available major street?

   Yes_____No_____

5. Suppose that it was possible to obtain accurate information on the freeway traffic condition at any time. How often would you use this information to plan your trips?

_____a. Always

_____b. Frequently

_____c. Occasionally

_____d. Never

6. Do you normally use the traffic and accident reports, that are given on various commercial radio stations, to plan your trips within the city during the morning and afternoon rush hours?

Yes_____No_____

Why?_____

_____

_____

_____

_____

7. Do you normally listen to the car radio?

Yes_____No_____

8. Do you normally watch television at home before you leave for work?

Yes_____No_____

9. Suppose that information about the freeway traffic conditions could be provided to you by any or all of the methods below. RANK these from 1 to 4, in the order of the method that would be most helpful to you.

RANK

_____a. Radio

_____b. Signs

_____c. Telephone Service

_____d. Television

List any other possible methods that you would recommend_____

_____

10. Below is a list of locations where information on freeway traffic conditions could be given. RANK these locations from 1 to 4, as to the order which would be most helpful to you in receiving such information.

RANK

_____a. On the freeway

_____b. On the major streets that you would take to the freeways

_____c. At the entrance ramps to the freeways

_____d. At the beginning of your trips, such as at home, office, etc.

11. If there is an unusual distrubance in the traffic flow on a freeway which is causing the traffic to move at a slower rate of speed than usual, which ONE of the following words would be most meaningful to you in describing this traffic condition, if it occurs at the following times.

a. During RUSH HOURS, when there are a large number of motorists going to or from work. (6:30 A.M. to 8:30 A.M. and 4:00 P.M. to 6:00 P.M.)

CHECK ONE

_____a. CONGESTION

_____b. EXTRA DELAY

_____c. FREEWAY BREAKDOWN

_____d. HEAVY CONGESTION

_____e. HEAVY TRAFFIC

_____f. JAMMED FREEWAY

_____g. SLOW TRAFFIC

_____h. STOP AND GO TRAFFIC

_____i. TRAFFIC JAM

List any other words that you would recommend_____

_____

_____

_____

b. Between RUSH HOURS, when the traffic on the freeway would usually be moderate or light. (8:30 A.M. to 4:00 P.M. and 6:00 P.M. to 6:30 A.M.)

CHECK ONE

_____a. CONGESTION

_____b. EXTRA DELAY

_____c. FREEWAY BREAKDOWN

_____d. HEAVY CONGESTION

_____e. HEAVY TRAFFIC

_____f. JAMMED FREEWAY

_____g. SLOW TRAFFIC

_____h. STOP AND GO TRAFFIC

_____i. TRAFFIC JAM

List any other words that you would recommend_____

_____

12. If the traffic flow on a freeway is what you would be expecting, which ONE of the following words would be most meaningful to you in describing this traffic condition for the following time periods:

a. During RUSH HOURS, when there are a large number of motorists going to or from work (6:30 A.M. to 8:30 A.M.and 4:00 P.M. to 6:00 P.M.)

CHECK ONE

_____a. CLEAR

_____b. FREE FLOWING TRAFFIC

_____c. NO DELAY

_____d. NORMAL

_____e. NORMAL TRAFFIC

_____f. UNCONGESTED

List any other words that you would recommend_____

_____

b. Between the RUSH HOURS, when the traffic on the freeway would usually be moderate or light. (8:30 A.M. to 4:00 P.M. and 6:00 P.M. to 6:30 A.M.)

CHECK ONE

_____a. CLEAR

_____b. FREE FLOWING TRAFFIC

_____c. NO DELAY

_____d. NORMAL

_____e. NORMAL TRAFFIC

_____f. UNCONGESTED

List any other words that you would recommend_____

_____

13. Below is a list of types of information that could be provided to tell the motorist about traffic conditions on freeways. Indicate the TWO that would be most helpful to you.

CHECK TWO

_____a. The degree of the congestion: Heavy,Moderate, Light

_____b. Location and length of a congested area

_____c. Travel time to various reference points ahead

_____d. The average travel speed obtainable between various reference points

_____e. Reason for the congested area such as accident, maintenance, stalled vehicle, etc.

List any other types of information that you would like to receive

_____

_____

14. Suppose you were given $100,000 to invest in the improvement revision of the existing signing for a freeway within a city. What proportion of the money would you allocate for each of the following?

SHOW THE AMOUNTS IN DOLLARS

_____a. Additional guide signs that would aid in directing you to various destinations

_____b. Advance signs that would give adequate warning of the change in traffic condition on the freeway and would advise what action the driver should take

_____c. Others_____

_____

_____

15. The colors used for freeway signing are white letters on green background for guide signs and black letters on yellow background for warning signs. In your opinion what color do you think a sign giving information on freeway traffic conditions should be?

_____a. Same as guide sign, white letters on green background

_____b. Same as warning sign, black letters on yellow background

_____c. New color combination to distinguish them from all other signs

_____d. Color is not important

PLEASE STOP AT THIS POINT

PART III.

CASE I.

1. RATE each sign in terms of how well it describes the freeway condition to you. These signs may receive EQUAL RATING. (Circle your choice).

   a. SIGN A:
   LOW - - - HIGH
   1 2 3 4 5

   b. SIGN B:
   LOW - - - HIGH
   1 2 3 4 5

   c. SIGN C:
   LOW - - - HIGH
   1 2 3 4 5

   d. SIGN D:
   LOW - - - HIGH
   1 2 3 4 5

2. RANK these signs from 1 to 4, in the order that best describes the freeway condition to you.

   RANK

   _____a. SIGN A

   _____b. SIGN B

   _____c. SIGN C

   _____d. SIGN D

3. What action would you take if you WERE PRESSED for time?

_____a. Proceed to the freeway and enter the main lanes at the Smith Avenue on ramp.

_____b. Proceed to the freeway and use the service road to bypass the congested area.

_____c. Remain on the parallel major street until you reach a street where another sign will inform you that the freeway is clear from that point north. Then proceed to the freeway.

_____d. Remain on the parallel major street to your destination, without even entering the freeway (assuming that this is possible).

4. What action would you take if you WERE NOT PRESSED for time?

_____a. Proceed to the freeway and enter the main lanes at the Smith Avenue on ramp.

_____b. Proceed to the freeway and use the service road to bypass the congested area.

_____c. Remain on the parallel major street until you reach a street where another sign will inform you that the freeway is clear from that point north. Then proceed to the freeway.

_____d. Remain on the parallel major street to your destination, without even entering the freeway (assuming that this is possible).

CASE II:

1. RATE each sign in terms of how well it describes the freeway condition to you. These signs may receive EQUAL RATING. (Circle your choice).

   a. SIGN A:
   LOW - - - HIGH
   1 2 3 4 5

   b. SIGN B:
   LOW - - - HIGH
   1 2 3 4 5

   c. SIGN C:
   LOW - - - HIGH
   1 2 3 4 5

   d. SIGN D:
   LOW - - - HIGH
   1 2 3 4 5

2. RANK these signs from 1 to 4, in the order that best describes the freeway condition to you.

   RANK

   _____a. SIGN A

   _____b. SIGN B

   _____c. SIGN C

   _____d. SIGN D

3. What action would you take if you WERE PRESSED for time?

_____a. Enter the main lanes of the freeway at Smith Avenue.

_____b. Continue on the service road until you reach the entrance ramp where another sign would indicate that the freeway main lanes are clear ahead of any heavy congestion.

_____c. Detour over to the parallel major street and continue to your destination (assuming that this is possible).

4. What action would you take if you WERE NOT PRESSED for time?

_____a. Enter the main lanes of the freeway at Smith Avenue.

_____b. Continue on the service road until you reach the entrance ramp where another sign would indicate that the freeway main lanes are clear ahead of any heavy congestion.

_____c. Detour over to the parallel major street and continue to your destination (assuming that this is possible).

CASE III:

1. RATE each sign in terms of how well it describes to you the change in the freeway traffic condition ahead. These signs may receive EQUAL RATING. (Circle your choice).

   a. SIGN A:
   LOW - - - HIGH
   1 2 3 4 5

   b. SIGN B:
   LOW - - - HIGH
   1 2 3 4 5

   c. SIGN C:
   LOW - - - HIGH
   1 2 3 4 5

   d. SIGN D:
   LOW - - - HIGH
   1 2 3 4 5

2. RANK these signs from 1 to 4, in the order that best describes to you the change in the Freeway condition ahead.

   RANK

   _____a. SIGN A

   _____b. SIGN B

   _____c. SIGN C

   _____d. SIGN D

3. What action would you take if you WERE PRESSED for time?

_____a. Continue driving at the same speed until you actually see that the traffic condition has changed.

_____b. Immediately reduce your speed for the anticipated change in traffic condition ahead and remain on the main lanes of the freeway.

_____c. Exit at the next off ramp and use the service road to bypass the congested area.

_____d. Exit at the next off ramp and continue to your point of destination by way of the parallel major street (assuming that this is possible).

4. What action would you take if you WERE NOT PRESSED for time?

_____a. Continue driving at the same speed until you actually see that the traffic condition has changed.

_____b. Immediately reduce your speed for the anticipated change in traffic condition ahead and remain on the main lanes of the freeway.

_____c. Exit at the next off ramp and use the service road to bypass the congested area.

_____d. Exit at the next off ramp and continue to your point of destination by way of the parallel major street (assuming that this is possible).

5. The following slides are several variations of a sign that was shown previously. Indicate your opinion of each variation.

A. _____a. Sign A is best

_____b. Sign B is best

_____c. Sign A and B are equally good

B. _____a. Sign B is best

_____b. Sign C is best

_____c. Both B and C are equally good

C. _____a. Sign C is best

_____b. Sign D is best

_____c. Both C and D are equally good

6. The next three slides are of a sign on which different symbols have been used to indicate the traffic condition. RANK these symbols from 1 to 3 in the order of your preference.

RANK

_____a. Red and Green circles are best

_____b. Red and Green arrows are best

_____c. Red and Green bars are best

APPENDIX - B

CHARACTERISTICS OF SURVEY PARTICIPANTS

Table B-1

SOCIAL AND DRIVING CHARACTERISTICS OF PARTICIPANTS

PARTICIPANTS BY SEX

Sex	Percent
Male	68
Female	32

PARTICIPANTS BY AGE

Age	Percent
24 or Under	24
25-44	45
45-64	31

PARTICIPANTS BY EDUCATIONAL LEVEL

Educational Level	Percent
Grade School	4
High School	29
Business College	12
Two Years of College	21
Graduated from College	34

PARTICIPANTS BY OCCUPATION

Occupation	Percent
Professional	30
Technician	26
Clerical	22
Salesworker	3
Craftsman	8
Service Worker	2
Other Blue Collar	4
Student	5

Table B-1 (Continued)

PARTICIPANTS BY DRIVER EDUCATION TRAINING RECEIVED

Training	Percent
None	45
Classroom	13
Behind the Wheel	15
Classroom and Behind the Wheel	27

PARTICIPANTS BY YEARS OF DRIVING EXPERIENCE

Driving Experience	Percent
0-4	5
5-14	36
15-24	21
25-34	22
35-44	13
45 or ABOVE	3

PARTICIPANTS BY MILES DRIVEN PER YEAR

Miles	Percent
Less than 8,000	14
8,000 - 12,000	28
12,000 - 18,000	37
18,000 - 30,000	18
OVER 30,000	3

PARTICIPANTS BY USE OF FREEWAY PER WEEK

Number of Trips	Percent
None	3
1-5	15
6-10	26
11-20	39
OVER 20	17

Table B-1 (Continued)

PARTICIPANTS BY USE OF FREEWAY TO AND FROM WORK

Normally Use Freeway	Percent
Yes	70
No	30

PARTICIPANTS BY PREFERENCE OF TRAVEL IN URBAN AREAS

Facility	Percent
Freeway	90
City Streets	10

Table B-2

COMPARISON OF LICENSED DRIVERS BY SEX AND AGE GROUPS

Age Groups	State of Texas Jan.1970* (%)		United States Feb. 1965* (%)		Questionnaire Respondents (%)	
	Male	Female	Male	Female	Male	Female
18-24	21	21	18	17	20	35
25-44	45	47	49	51	44	47
45-64	34	32	33	32	36	18

*These percentages are based upon total licensed drivers between the age level of 18 to 64 years of age.

Table B-3

COMPARISON OF LICENSED DRIVERS BY SEX

	State of Texas Jan. 1970* (%)	United States Feb. 1965* (%)	Questionnaire Respondents (%)
Male	55	58	68
Female	45	42	32

*These percentages are based upon all licensed drivers.

APPENDIX - C

STATISTICAL TESTS FOR RANKING CONSISTENCY

Table C-1

KENDALL'S TEST FOR RANKING - LOCATIONS OF COMMUNICATION

	On the Freeway		On the Major Streets		At the Entrance Ramps		At the Beginning of Trip		TOTAL	
RANK	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	38	152	156	624	71	284	189	756	454	1816
2	62	186	177	531	165	495	50	150	454	1362
3	152	304	82	164	188	376	32	64	454	908
4	202	202	39	39	30	30	183	183	454	454
R_j		844		1358		1185		1153		4540

$$\bar{R} = \frac{\Sigma R_j}{N} = 1135$$

$$S = \Sigma (R_j - \bar{R})^2 = 137{,}234$$

$$W = \frac{12 \quad S}{K^2 \quad (N^3 - N)} = 0.1332$$

$$\chi^2 = k\,(N-1)\,W = 181.4^{**}$$

$$d.f. = 3$$

Table C-2

KENDALL'S TEST FOR RANKING SIGN DESIGN ALTERNATIVES - CASE 1

	Design 1		Design 2		Design 3		Design 4		TOTALS	
RANK	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	182	728	113	452	57	228	54	216	406	1624
2	120	360	157	471	74	222	55	165	406	1218
3	78	156	68	136	165	330	95	190	406	812
4	26	26	68	68	110	110	202	202	406	406
R_j		1270		1127		890		773		4060

$$\bar{R} = \frac{\Sigma R_j}{N} = 1015$$

$$S = \Sigma (R_j - \bar{R})^2 = 151,758$$

$$W = \frac{12S}{K^2 (N^3 - N)} = 0.18413$$

$$\chi^2 = K(N-1)w = 224.3^{**}$$

d.f. = 3

Table C-3

KENDALL'S TEST FOR RANKING SIGN DESIGN ALTERNATIVES - CASE II

	Design 1		Design 2		Design 3		Design 4		TOTALS	
RANK	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	234	936	73	292	59	236	47	188	413	1652
2	87	261	161	483	79	237	86	258	413	1239
3	48	96	95	190	135	270	135	270	413	826
4	44	44	84	84	140	140	145	145	413	413
R_j		1337		1049		883		861		4130

$$\bar{R} = \frac{\Sigma R_j}{N} = 1032.5$$

$$S = \Sigma (R_j - \bar{R})^2 = 144{,}755$$

$$W = \frac{12S}{K^2 (N^3 - N)} = 0.16973$$

$$\chi^2 = K(N-1)w = 210.3^{**}$$

d.f. = 3

Table C-4

KENDALL'S TEST FOR RANKING SIGN DESIGN ALTERNATIVES - CASE III

	Design 1		Design 2		Design 3		Design 4		TOTALS	
RANK	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	209	836	106	424	45	180	63	252	423	1692
2	106	318	195	585	70	210	52	156	423	1269
3	55	110	89	178	172	344	107	214	423	846
4	53	53	33	33	136	136	201	201	423	423
R_j		1317		1220		870		823		4230

$$\bar{R} = \frac{\Sigma R_j}{N} = 1057.5$$

$$S = (R_j - \bar{R})^2 = 183,893$$

$$W = \frac{12S}{K^2 (N^3 - N)} = .2055$$

$$\chi^2 = K(N-1)w = 260.8^{**}$$

d.f. = 3

Table C-5

KENDALL'S TEST FOR RANKING
SPECIAL VISUAL SYMBOLS

	Circle		Arrow		Bar		TOTALS	
RANK	Number	Points	Number	Points	Number	Points	Number	Points
1	175	525	92	276	70	210	337	1011
2	85	170	177	354	75	150	337	674
1	77	77	68	68	192	192	337	337
R_j		772		698		552		2022

$$\bar{R} = \frac{\Sigma R_j}{N} = 674$$

$$S = \Sigma (R_j - \bar{R})^2 = 25064$$

$$W = \frac{12S}{K^2 (N^3 - N)} = 0.01128$$

$$\chi^2 = K(N-1)w = 7.60272$$

d.f.=2

APPENDIX - D

TABLES AND FIGURES SUMMARIZING THE RESULTS OF SUBGROUP ANALYSIS

Table D-1

SUMMARY OF PROBABLE DIVERSION TO AN AVAILABLE MAJOR STREET ASSUMING INFORMATION WAS AVAILABLE REGARDING AN UNUSUAL CONDITION ON THE FREEWAY

	Alternative	All Respondents (%)	Respondents who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Condition:	Peak Period-Information Before Entering Freeway					
	Would Divert	92	91	96	92	96
	Would Not Divert	8	9	4	8	4
Condition:	Peak Period-Information Given After Entering Freeway					
	Would Divert	75	74	70	75	78
	Would Not Divert	25	26	22	25	22
Condition:	Off Peak-Information Given After Entering Freeway					
	Would Divert	70	69	73	70	74
	Would Not Divert	30	31	27	30	26

Table D-2

PARTICIPANT RESPONSE TO REAL-TIME INFORMATION PROVIDED ON A PARALLEL MAJOR ARTERIAL WHEN PRESSED FOR TIME

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Proceed to the freeway and enter the main lanes at the Smith Avenue on-ramp.	1	1	1	1	0
Proceed to the freeway and use the service road to bypass the congested area.	14	14	13	14	17
Remain on the parallel major street until they reach a street where another sign will inform them that the freeway is clear from that point north. Then proceed to the freeway.	75	76	75	77	62
Remain on the parallel major street to their destination assuming that this is possible.	10	9	11	8	21

Table D-3

PARTICIPANT RESPONSE TO REAL-TIME INFORMATION PROVIDED ON A PARALLEL MAJOR ARTERIAL WHEN NOT PRESSED FOR TIME

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Proceed to the freeway and enter the main lanes at the Smith Avenue on-ramp.	3	3	3	3	9
Proceed to the freeway and use the service road to bypass the congested area.	16	16	15	16	9
Remain on the parallel major street until they reach a street where another sign will inform them that the freeway is clear from that point north. Then proceed to the freeway.	57	57	58	59	40
Remain on the parallel major street to their destination, assuming that this is possible.	24	24	24	22	42

Table D-4

PARTICIPANT RESPONSE TO REAL-TIME INFORMATION PROVIDED AT THE FREEWAY ENTRANCE RAMPS WHEN PRESSED FOR TIME

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Enter the main lanes of the freeway at Smith Avenue.	1	1	1	1	0
Continue on the service road until they reach the entrance ramp, where another sign would indicate that the freeway main lanes were clear ahead of any heavy congestion.	86	86	86	86	91
Detour over to the parallel major street and continue to their destination, assuming that this is possible.	13	13	13	13	9

Table D-5

PARTICIPANT RESPONSE TO REAL-TIME INFORMATION PROVIDED AT THE FREEWAY ENTRANCE RAMPS WHEN NOT PRESSED FOR TIME

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Enter the main lanes of the freeway at Smith Avenue.	4	4	4	5	2
Continue on the service road until they reach the entrance ramp, where another sign would indicate that the freeway main lanes were clear ahead of any heavy congestion.	75	75	74	77	53
Detour over to the parallel major street and continue to their destination, assuming that this is possible.	21	21	22	18	45

Table D-6

PARTICIPANT RESPONSE TO REAL-TIME INFORMATION ON THE FREEWAY WHEN PRESSED FOR TIME

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Continue driving at the same speed until they actually see that the traffic condition has changed.	4	5	2	4	4
Immediately reduce their speed for the anticipated change in traffic condition ahead and remain on the main lanes of the freeway	12	14	6	12	4
Exit at the next off-ramp and use the service road to bypass the congested area.	69	68	71	69	70
Exit at the next off-ramp and continue to their point of destination by way of the parallel major street, assuming that this is possible.	15	13	21	15	22

Table D-7

PARTICIPANT RESPONSE TO REAL-TIME INFORMATION ON THE FREEWAY WHEN NOT PRESSED FOR TIME

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
Continue driving at the same speed until they actually see that the traffic condition has changed.	11	11	11	11	4
Immediately reduce their speed for the anticipated change in traffic condition ahead and remain on the main lanes of the freeway.	28	28	28	29	22
Exit at the next off-ramp and use the service road to bypass the congested area.	42	43	40	42	41
Exit at the next off-ramp and continue to their point of destination by way of the parallel major street, assuming that this is possible.	19	18	21	18	33

Table D-8

PARTICIPANT RESPONSE TO PREFERENCE OF TYPE OF REAL-TIME INFORMATION

Alternative	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
The degree of the congestion: Heavy, Moderate, Light.	69	69	69	69	64
Location and length of a congested area.	71	71	70	71	68
Travel time to various reference points ahead.	7	7	9	8	6
The average travel speed obtainable between various reference points.	13	13	14	13	11
Reason for the congested area, such as accident, maintenance, stalled vehicle, etc.	40	40	38	38	51

Table D-9

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME INFORMATION

	Location	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking Points*	Standard Deviation
I.	Respondents Who Normally Drive the Freeway to and from Work						
	On The Freeway	10	14	35	41	2.0	0.9
	On The Major Street	35	35	18	12	3.0	0.9
	At The Entrance Ramps	15	40	39	6	2.7	0.8
	At The Beginning of Trip	40	11	8	41	2.6	.3
II.	Respondents Who Do Not Drive the Freeway to and from Work						
	On The Freeway	5	13	30	52	1.8	0.8
	On The Major Street	33	47	19	1	3.2	0.7
	At The Entrance Ramps	18	30	45	7	2.6	0.8
	At The Beginning of Trip	44	10	6	40	2.6	1.3
III.	Respondents Who Prefer Freeways						
	On The Freeway	9	14	33	44	1.9	0.9
	On The Major Street	33	39	19	9	3.0	0.9
	At The Entrance Ramps	15	37	41	7	2.7	0.8
	At The Beginning of Trip	43	10	7	40	2.6	1.3

Table D-9 (Cont.)

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING
REAL-TIME INFORMATION

Location	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking Points*	Standard Deviation
IV. Respondents Who Prefer City Streets						
On The Freeway	0	13	37	50	1.7	0.7
On The Major Street	43	37	13	7	3.2	0.9
At The Entrance Ramps	20	35	43	2	2.8	0.8
At The Beginning of Trip	37	15	7	41	2.5	1.3

*Based on assigning 4 points for each 1st choice, 3 points for each 2nd choice, 2 points for each 3rd choice, and 1 point for each 4th choice. Maximum possible Mean = 4.0; Minimum Possible Mean = 1.0.

Table D-10

SUMMARY OF AVERAGE RATINGS AND RANKINGS
FOR SIGN DESIGN ALTERNATIVES -
CASE I

RATING

Design	All Respondents (Average)	Respondents Who Normally Drive the Freeway to & from Work (Average)	Respondents Who Do Not Normally Drive the Freeway to & from Work (Average)	Respondents Who Prefer Freeways (Average)	Respondents Who Prefer City Streets (Average)
Design 1	4.0	4.0	3.9	4.0	4.1
Design 2	3.5	3.5	3.4	3.4	3.6
Design 3	2.5	2.6	2.3	2.5	2.2
Design 4	2.4	2.3	2.5	2.4	2.4

RANKING

Design	All Respondents (Average)	Respondents Who Normally Drive the Freeway to & from Work (Average)	Respondents Who Do Not Normally Drive the Freeway to & from Work (Average)	Respondents Who Prefer Freeways (Average)	Respondents Who Prefer City Streets (Average)
Design 1	3.2	3.2	3.1	3.2	3.3
Design 2	2.8	2.9	2.7	2.8	2.9
Design 3	2.2	2.2	2.3	2.2	2.2
Design 4	2.0	1.9	2.1	2.0	1.8

Table D-11

SUMMARY OF AVERAGE RATINGS AND RANKINGS
FOR SIGN DESIGN ALTERNATIVES
CASE II

RATING

Design	All Respondents (Average)	Respondents Who Normally Drive the Freeway to & from Work (Average)	Respondents Who Do Not Normally Drive the Freeway to & from Work (Average)	Respondents Who Prefer Freeways (Average)	Respondents Who Prefer City Streets (Average)
Design 1	3.9	3.9	3.9	3.9	4.2
Design 2	2.8	2.9	2.7	2.8	3.1
Design 3	2.7	2.7	2.7	2.7	3.0
Design 4	2.4	2.4	2.4	2.4	2.5

RANKING

Design	All Respondents (Average)	Respondents Who Normally Drive the Freeway to & from Work (Average)	Respondents Who Do Not Normally Drive the Freeway to & from Work (Average)	Respondents Who Prefer Freeways (Average)	Respondents Who Prefer City Streets (Average)
Design 1	3.3	3.3	3.3	3.3	3.4
Design 2	2.6	2.6	2.6	2.6	2.9
Design 3	2.1	2.2	2.1	2.2	2.0
Design 4	2.2	2.1	2.3	2.2	1.9

Table D-12

SUMMARY OF AVERAGE RATINGS AND RANKINGS
FOR SIGN DESIGN ALTERNATIVES -
CASE III

RATING

Design	All Respondents (Average)	Respondents Who Normally Drive the Freeway to & from Work (Average)	Respondents Who Do Not Normally Drive the Freeway to & from Work (Average)	Respondents Who Prefer Freeways (Average)	Respondents Who Prefer City Streets (Average)
Design 1	4.1	4.1	4.0	4.0	4.2
Design 2	3.6	3.6	3.5	3.6	3.5
Design 3	2.8	2.8	2.8	2.8	3.0
Design 4	2.4	2.4	2.4	2.4	2.5

RANKING

Design	All Respondents (Average)	Respondents Who Normally Drive the Freeway to & from Work (Average)	Respondents Who Do Not Normally Drive the Freeway to & from Work (Average)	Respondents Who Prefer Freeways (Average)	Respondents Who Prefer City Streets (Average)
Design 1	3.2	3.2	3.1	3.2	3.2
Design 2	2.9	2.9	2.9	2.9	2.9
Design 3	2.1	2.1	2.1	2.1	2.2
Design 4	2.0	2.0	2.0	2.0	1.9

Table D-13

GROUP ANALYSIS OF PREFERENCES OF WORDS FOR DESCRIBING
UNUSUAL TRAFFIC CONDITIONS DURING THE PEAK PERIODS

Words	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
CONGESTION	17	18	14	17	17
EXTRA DELAY	5	4	6	5	6
FREEWAY BREAKDOWN	3	3	2	3	0
HEAVY CONGESTION	30	30	34	31	25
HEAVY TRAFFIC	7	6	9	6	16
JAMMED FREEWAY	12	12	13	12	8
SLOW TRAFFIC	4	4	3	4	4
STOP & GO TRAFFIC	12	11	12	12	12
TRAFFIC JAM	10	12	6	10	12

Table D-14

GROUP ANALYSIS OF PREFERENCES OF WORDS FOR DESCRIBING UNUSUAL TRAFFIC CONDITIONS DURING THE OFF PEAK PERIODS

Words	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
CONGESTION	28	32	21	29	27
EXTRA DELAY	5	5	5	5	4
FREEWAY BREAKDOWN	3	3	2	3	0
HEAVY CONGESTION	12	10	16	11	17
HEAVY TRAFFIC	9	9	11	10	4
JAMMED FREEWAY	5	5	5	5	2
SLOW TRAFFIC	24	21	30	23	34
STOP & GO TRAFFIC	9	9	8	9	8
TRAFFIC JAM	5	6	2	5	4

Table D-15

GROUP ANALYSIS OF PREFERENCES OF WORDS FOR DESCRIBING USUAL TRAFFIC CONDITIONS DURING THE PEAK PERIODS

Words	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
CLEAR	6	6	4	5	4
FREE FLOWING TRAFFIC	19	19	20	20	20
NO DELAY	3	3	5	4	2
NORMAL	40	42	34	40	35
NORMAL TRAFFIC	29	27	34	27	37
UNCONGESTED	3	3	4	4	2

Table D-16

GROUP ANALYSIS OF PREFERENCE OF WORDS FOR DESCRIBING USUAL TRAFFIC CONDITIONS DURING THE PEAK PERIODS

Words	All Respondents (%)	Respondents Who Normally Drive the Freeway to & from Work (%)	Respondents Who Do Not Normally Drive the Freeway to & from Work (%)	Respondents Who Prefer Freeways (%)	Respondents Who Prefer City Streets (%)
CLEAR	13	14	10	14	4
FREE FLOWING TRAFFIC	20	19	22	20	21
NO DELAY	4	4	5	5	2
NORMAL	36	38	33	35	45
NORMAL TRAFFIC	22	21	23	22	22
UNCONGESTED	5	4	7	5	6

Table D-17

RESULTS OF PAIRED COMPARISONS OF DESIGN ALTERNATIVES OF SPECIAL DISPLAYS

Test I Selection	All Respondents (%)	Respondents Who Drive Freeway to Work (%)	Respondents Who Do Not (%)	Respondents Who Prefer Freeway (%)	Respondents Who Prefer City Streets (%)
Alternative A	6	6	6	6	8
Alternative B	87	87	87	87	83
No Preference	7	7	7	7	9
Test II Selection	**All Respondents (%)**	**Respondents Who Drive Freeway to Work (%)**	**Respondents Who Do Not (%)**	**Respondents Who Prefer Freeway (%)**	**Respondents Who Prefer City Streets (%)**
Alternative A	69	72	64	71	52
Alternative B	21	19	26	20	38
No Preference	10	9	10	9	10
Test III Selection	**All Respondents (%)**	**Respondents Who Drive Freeway to Work (%)**	**Respondents Who Do Not (%)**	**Respondents Who Prefer Freeway (%)**	**Respondents Who Prefer City Streets (%)**
Alternative A	26	27	25	27	25
Alternative B	57	55	61	57	53
No Preference	17	18	13	16	22