APPLICATION OF COMMERCIAL RADIO TO FREEWAY COMMUNICATIONS - A STUDY OF DRIVER ATTITUDES

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ABSTRACT

Ramp metering has proven to be an effective means of improving the operational efficiency of an over-crowded urban freeway. Freeway control systems can now prevent a breakdown under "normal" conditions. However, adequate control of demand under "abnormal" conditions, such as accidents or lane blockages, is not possible. Real-time driver communications is therefore necessary to increase safety and efficiency.

One method of transmitting information to the driver is through the use of commercial radio. This study discusses the results of a questionnaire survey directed toward the evaluation of commercial radio for real-time freeway communications. The conclusion is reached that commercial radio could play a vital role as part of an effective real-time traffic information system for urban freeways.

SUMMARY

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 specific objective of the project is to investigate the application of commercial radio to freeway communications. This report is concerned with a questionnaire study designed to provide specific inputs to the above objective. Based on the analysis of the questionnaire survey administered to 505 motorists (327 from Houston and 178 from Dallas), the following conclusion may be drawn:

1. Commercial radio could play a vital role as part of an effective real-time traffic information system for urban freeways. This conclusion is based on the following findings:
   a. Motorists expressed a willingness to divert to an alternate arterial street if they had knowledge of an unusual condition on the freeway and provided that a suitable alternate route were available. The motorists would be more inclined to divert before they entered the freeway than they would once on the freeway.
   b. Forty-seven percent of the respondents indicated that they would always use information about freeway traffic conditions to plan their trips if the information were accurate. Another 38 percent responded that they would frequently use the information.

c. Sixty-two percent of the participants, who had car radios and who could benefit from radio reports of freeway conditions, currently use radio traffic bulletins for trip planning during the peak period. There were indications that this percentage would increase if the information were more accurate and timely.

d. Eighty-nine percent of the participants indicated that they normally listen to the car radio.

e. The participants ranked their preferences of four modes of communication according to the following order:

1) Radio
2) Signs
3) Television
4) Telephone

The above rankings were based on the R_j values of Kendall's Coefficient of Concordance (5). Further evaluation of the results indicated that there did not appear to be any appreciable difference between the preference for radio and the preference for signs, in spite of the ranking resulting from Kendall's test.

f. Motorists expressed preferences for receiving information about freeway traffic conditions before they enter the freeway and at locations where decisions can be made with respect to the selection of alternate routes. The following represents the consensus of preference based on Kendall's test:

1) On the major street
2) At the entrance ramps
3) At the beginning of trip
4) On the freeway

g. The findings shown in item f are based on average values. Analysis of first choice preferences revealed that 42 percent of the participants considered information at the beginning of the trip to be their highest preference, 34 percent chose to receive information on the major street as their first preference, 16 percent chose the entrance ramps and 8 percent preferred information on the freeway itself.

h. There was a major division in attitudes toward the preference for traffic information at the beginning of the trip. Forty-two percent selected this location alternative as their first choice, whereas 40 percent indicated that this alternative was least preferred.

i. There appears to be a relationship between the preference of communication mode and the preference for receiving information at the beginning of the trip.

   1) The motorists who selected the beginning of trip as their first choice of location ranked radio as their preferred mode of communication.

   2) The motorists who considered traffic information at the beginning of trip of least value placed a high preference on signs.

   3) The motorists who ranked radio as the most preferred mode of communication placed a high emphasis on receiving information at the beginning of the trip and on the major streets. The preference for these two location alternatives was approximately equal.

4) The motorists who chose signs as the preferred mode of communication placed high emphasis for traffic information on the major streets and at the entrance ramps. Information at the beginning of the trip and on the freeway were the least preferred alternatives.

j. There did not appear to be any appreciable differences in the responses to the questions between the Houston participants and those in Dallas.

Recommendations For Implementation

Based on the results of this study, the following recommendations are offered:

1. Commercial radio should be further developed as an integral part of a real-time traffic information system for urban freeways.
2. The alternatives available to the Highway Department regarding the process of communicating via the radio should be identified and evaluated. Some alternatives include the following:
   a. Providing information to the radio stations directly from a freeway surveillance and control center and allowing the station to decide when to broadcast the information
   b. Buying prime radio time during the peak periods and providing freeway traffic information as a public service
   c. Acquiring a separate frequency to broadcast during the peak periods
   d. Using induction radio systems that broadcast over any existing station on the car radio

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INTRODUCTION

Statement of the Problem

The continued and rapid growth of traffic demand in urban areas is paralleled by an increasing severity of freeway congestion. Studies have shown that even a relatively small increase in traffic demand on an already crowded freeway can have detrimental effects on a large portion of the freeway system. Speeds and throughput volumes are substantially reduced, travel times and traffic impedances increase significantly, and safety is impaired.

The freeway congestion problem led to the development of a ramp control system as a means of regulating demand. The metering of freeway entrance ramps proved to be an effective means of improving the operational efficiency of an over-crowded freeway. Freeway control systems can now prevent a breakdown under "normal" conditions. However, adequate control of demand under "abnormal" conditions, such as accidents or lane blockages, is not possible. Real-time driver communications is therefore a necessary part of the control system as a means of increasing safety and efficiency.

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 which culminated in an operational freeway ramp control system. A relevant mission of the project is to develop a real-time driver information system for an urban freeway corridor. Some particular questions which must be

resolved in the study are as follows:

1) What type of message carrier is required?

2) What type of information must be conveyed?

3) Where is the optimum location for transmitting the information?

4) What should be the criteria for activation of the real-time information system?

5) What types of surveillance techniques and equipment are necessary for real-time driver communications?

One method of transmitting real-time information to the driver is through the use of commercial radio. This research is concerned with the evaluation of driver attitudes toward the application of commercial radio for freeway communications.

Objectives

The specific objective of this portion of the research effort was to investigate the application of commercial radio to freeway communications. The subobjectives were to resolve the following questions:

1) What is the potential usage of real-time freeway traffic information?

2) What is the current usage of radio for freeway traffic information?

3) What are the limitations of the current methods of broadcasting freeway traffic information?

4) What is the potential of this mode of communication for effective information systems design?

Previous Work

Radio stations in many cities broadcast traffic conditions on major routes daily during the peak periods. The radio stations receive the information from either the local police or from radio station personnel

reporting from helicopters circling the city or reporting from automobiles positioned at strategic locations along freeways and major arterials. The effectiveness of the reports is not completely known because of the lack of quantified data for its evaluation.

An attempt was made by Weinberg, et.al. (1) to evaluate traffic reporting from a helicopter. A questionnaire was sent to motorists affected by one specific incident. Using these data, the traffic situation was reconstructed to estimate the following:

1) The amount of delay incurred by drivers who became involved in the traffic tie-up

2) The amount of delay that could have been incurred by drivers who would have been involved in the tie-up without helicopter traffic reporting

3) The additional travel time incurred by drivers using an alternate route as a result of heeding the helicopter traffic reports

The results of the study indicated a net saving of 361 vehicle hours of travel due to the helicopter reports. No attempt was made to evaluate driver attitudes toward receiving the traffic reports via commercial radio.

Although no data or reports are available, one of the authors recalls an attempt by a local radio station in Detroit to evaluate motorist use of freeway traffic reports provided by the station during the peak periods. Personnel, who in many cases were retired police officers, were stationed in automobiles at locations along the freeway system. These men broadcasted information about the traffic situations. The radio station asked their listeners to send a post card to the station to indicate their use of the reports. To the authors' knowledge, no report on the response of the motorists is available. However, the station personnel were soon

removed from their duty of reporting on freeway traffic conditions, and this method was discontinued by the radio station.

The Automobile Club of Southern California (2) conducted a questionnaire survey of their members in 1967 to help determine the effectiveness, accuracy and completeness of freeway traffic advisory radio broadcasts in the Los Angeles area. Several radio stations in the area broadcast traffic bulletins which are received from the California Highway Patrol, Sheriff's Department, or the Los Angeles Police Department. The results of the survey indicated that broadcast alerts were popular with the motorists. However, the coverage by the radio stations was considered to be spotty.

Heathington, et.al, (3) reported a study in which driver attitudes toward real-time freeway information were evaluated. A home questionnaire survey was used to evaluate driver attitudes concerning priorities associated with expenditures for transportation improvements on expressways for the Chicago area. Each respondent was furnished ten envelopes, nine of which had predetermined descriptors listed on them and one structured so that the respondent could write in an additional descriptor not listed on the other nine. One of the descriptors was to "provide additional radio traffic reports." Each respondent was given the envelopes in random order and was asked to budget $100.00 in play money in any manner he wished on any or all of the descriptors. Heathington concluded that the priorities of the sample for the Chicago area were as follows:

1) Better repair of pavement damages such as holes, bumps, etc. (Descriptor A)

2) Increased enforcement of regulations concerning shoulder riding, lane changing, driving speed (minimum and maximum), etc. (Descriptor B)

3) Provision of signs that can be electronically changed to furnish information about traffic conditions on the expressway ahead (Descriptor C)

4) Other (Descriptor D)

5) Complete removal of stalled vehicles and vehicles involved in accidents from the expressway (Descriptor E)

6) Provision along the route of free telephones which are only connected to the highway or police department and which can be used by the motorist to call for assistance (Descriptor F)

7) Better maintenance of painted lines on pavement that separate lanes (Descriptor G)

8) Construction of more entrance ramps (Descriptor H)

9) Provision of additional radio traffic reports (Descriptor I)

10) Reduction of the number of entrance ramps (Descriptor J)

The results of the study are shown in Table 1.

Heathington further analyzed the "dominant" descriptors by the number of respondents who chose to allocate all of their play money to the first, second, third, etc., descriptors, respectively. The results of total allocation to one, two, and three descriptors is presented in Table 2. Based on this analysis, he concluded that descriptors A, B, and C dominated. He further noted that, based on total allocation to one descriptor, the provision of freeway assistance telephones (Descriptor F) ranked sixth, while the provision of additional radio traffic reports (Descriptor I) ranked tenth. Heathington concludes, "In general, the respondents interviewed had a preference for information items."

Without an intimate knowledge of the conditions in the Chicago area which may have led to the selection of priorities by the local motorists, it is very difficult to extrapolate the results to other major cities. For example, the need for changeable message signs was rated relatively

TABLE 1

EXPENDITURES FOR TRANSPORTATION IMPROVEMENTS ON EXPRESSWAYS FOR CHICAGO DRIVERS (3)

Descriptor	Mean	Order of Mean Expenditure	Standard Deviation	Percent Spending Money on Item	Percent Allocating A Maximum Expenditure to Item	Ranking by Allocation of Maximum Expenditure to Item
A. Better repair of pavement damages such as holes, bumps, etc.	$20.84	1	22.53	65.98	37.04	1
B. Increased enforcement of regulations concerning shoulder riding, lane changing, driving speed (minimum and maximum), etc.	16.22	2	20.51	61.04	26.20	2
C. Provision of signs that can be electronically changed to furnish information about traffic conditions on the expressway ahead.	15.47	3	18.35	63.92	21.54	3
D. Other, please specify	11.49	4	24.77	26.06	17.15	4
E. Complete removal of stalled vehicles and vehicles involved in accidents from the expressway.	10.49	5	14.99	52.67	14.68	5

Descriptor	Mean	Order of Mean Expenditure	Standard Deviation	Percent Spending Money on Item	Percent Allocating A Maximum Expenditure to Item	Ranking by Allocation of Maximum Expenditure to Item
F. Provision along the route of free telephones which are only connected to the highway or police department and can be used by the motorist to call for assistance.	8.54	6	12.43	50.62	10.56	6(tie)
G. Better maintenance of painted lines on pavement that separate lanes.	8.06	7	12.51	44.44	10.56	6(tie)
H. Construction of more entrance ramps.	3.79	8	11.76	17.97	5.49	8
I. Provision of additional radio traffic reports.	2.82	9	6.61	22.63	2.61	10
J. Reduction of the number of entrance ramps.	2.28	10	7.27	12.62	2.74	9

TABLE 2

CROSS TABULATIONS OF PERCENT OF RESPONDENTS ALLOCATING TOTAL EXPENDITURES FOR A GIVEN NUMBER OF DESCRIPTORS FOR CHICAGO EXPRESSWAYS (3)

Number of Items Chosen for Total Expenditure	Descriptors Chosen For Expenditures									
	A	B	C	D	E	F	G	H	I	J
1	1.92	2.06	1.23	3.43	.69	.14	.27	.69	0	0
2	5.90	3.16	4.80	2.06	1.92	2.88	2.33	.27	.14	.14
3	10.01	10.01	9.05	4.66	6.17	4.94	4.80	1.51	1.78	2.19

high, while the need for additional radio reports on traffic conditions was of low priority. This, perhaps, could mean that the information provided by the local radio stations is adequate to meet the needs of the motorists.

RESEARCH APPROACH

The resolution of the basic questions raised in the previous section was approached by means of 1) a television-radio study and 2) a questionnaire study. This report is a documentation of the results of the questionnaire study; the television-radio study will be documented in another report. The following sections describe the mechanics of each of the studies.

Television-Radio Study

This study is concerned with the evaluation of the current accuracy, reliability, and timeliness of freeway traffic information by commercial radio. The section of the Gulf Freeway currently under closed circuit television surveillance is monitored daily from the control center. A daily activity at the center is to log freeway traffic incidents such as accidents, disabled vehicles, or other occurrences which affect the normal flow of traffic during the peak periods. For the purposes of this study, three local radio stations, which broadcast peak period traffic bulletins, are being monitored with magnetic voice tape recorders during the morning peak periods. The tapes are then transcribed, and information relating to the study section of the Gulf Freeway is recorded on prepared data forms. The following information is noted:

1) Whether the station did provide a report of an incident
2) The time of the broadcast (or broadcasts) relating to a specific incident
3) The accuracy of the traffic report
4) Whether the station did provide a report when the incident had been cleared or removed

These data will thus form a foundation for evaluating the discrepancies between actual events and the radio reports.

Questionnaire Study

One of the primary objectives of the Freeway Control and Information Systems Project is to develop functional requirements for a freeway communications system. It was reasoned that the motoring public could and should play a major role in establishing the system design, since the system must fulfill their needs. The system must be designed such that the information provided is meaningful, timely, and useful to the motorists in traveling the freeway system safely and conveniently. Consequently, a research team with expertise in traffic and transportation engineering, psychology, human factors and statistics designed a questionnaire which would provide valuable input for the system design.

The questionnaire was administered to employees of several organizations in Houston and Dallas. The participants were selected at random from each organization. No restrictions were placed on the selection, except the requirement that they be licensed drivers. The data were recorded on computer cards for reduction and analysis. The design of this comprehensive questionnaire survey was reported by Dudek and Jones (4). The reader is referred to that publication for a detailed discussion of the survey. A portion of the questionnaire was designed to provide specific input for the study of the application of commercial radio to freeway communications. The results of that portion of the questionnaire form the basis for this report.

Potential Use of Real-Time Traffic Information - To establish the potential use of real-time information for route selection in an urban freeway corridor, the following questions were asked of the questionnaire participants:

1. 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 _____

2. 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 _____

3. 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

Current Use of Commercial Radio for Route Selection - The current usage of commercial radio traffic and accident reports and the limitations of this type of system were evaluated by asking the following:

1. 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? _____

   _____

Potential of Commercial Radio for Effective Systems Design - To evaluate the potential of commercial radio as an integral part of an urban freeway driver communications system, the following statements were incorporated in the questionnaire:

1. Do you normally listen to the car radio?

   Yes _____ No _____

2. 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.

   _____a. Radio
   _____b. Signs
   _____c. Telephone Service
   _____d. Television

   List any other possible methods that you would recommend_____

   _____

3. 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.

   _____a. On the freeway
   _____b. On the major streets that you would take to the freeway
   _____c. At the entrance ramps to the freeway
   _____d. At the beginning of your trips, such as at home, office, etc.

RESULTS

General

The questionnaire was administered to 505 persons, 327 of these from Houston and 178 from Dallas. The data were combined and analyzed as a total sample. Analyses were also performed on the sample from each city to determine any differences in patterns of the responses of the participants. The reader is referred to Table 12 in the Appendix for a summary of the social and driving characteristics of the persons who participated in the survey.

Potential Use of Real-Time Traffic Information

A summary of the responses to the questions relating to the use of real-time freeway traffic information is presented in Table 3 and Figure 1. The results indicate that the majority of the motorists would be inclined to divert if they had knowledge of an unusual condition on the freeway and provided a suitable alternate route were available. Once the motorist has entered the freeway, he is less inclined to leave the freeway to seek an alternate route. 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 an 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 responded that they would be inclined to leave the freeway to use the major street.

In the study reported by Dudek and Jones (4), analysis was made of the reaction toward real-time freeway information using a slide presentation

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 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, Information Given After Entering Freeway	
	Would Divert	70
	Would Not Divert	30

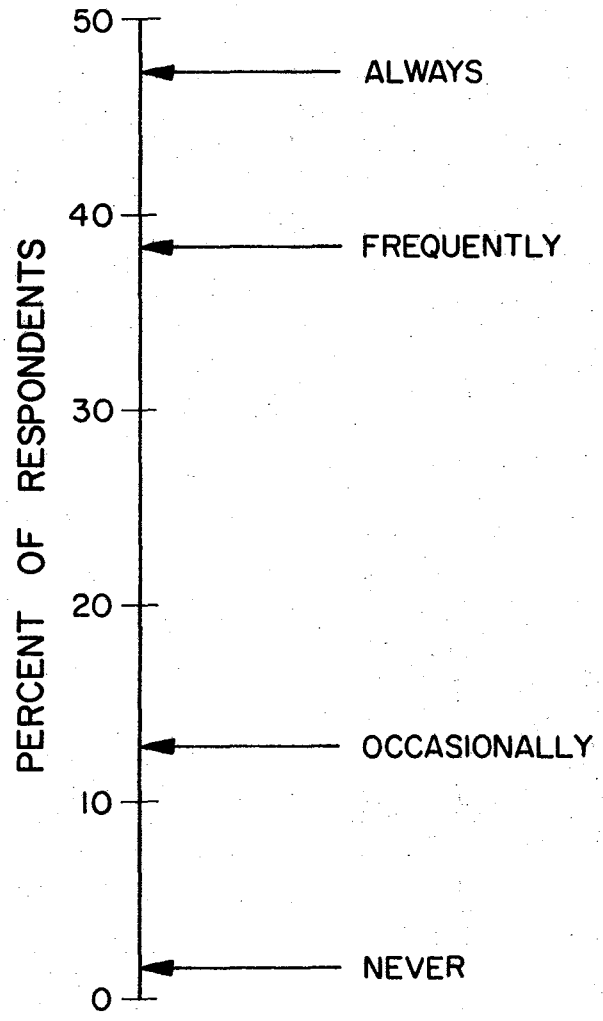

FIGURE 1 - DRIVER USE OF REAL-TIME FREEWAY INFORMATION

which placed the respondents in hypothetical driving situations. The results further indicated that the majority of drivers would use the information by rerouting their trips. They would use either the service roads or major streets, depending upon their location when informed of the condition. However, there is a strong desire to use the freeway; the majority of drivers would use the alternate routes only to bypass the congested area and would return to the freeway as soon as possible.

An estimate of the probable use of real-time freeway traffic information is of importance. The results in Figure 1 show that 47 percent of the participants indicated that they would "always" use information on freeway traffic conditions to plan their trips if the information were accurate, while 38 percent responded that they would "frequently" use the information. One would expect that about 85 percent would at least "frequently" use accurate real-time freeway traffic information to plan their trips. This figure is slightly lower than the 92 percent who indicated the use of the information to divert to an available arterial street during the peak periods. The difference may possibly stem from the intent and manner in which the question was asked. The response to the question relating to diversion was made with the understanding that an arterial street would be available to use. The response to the latter question may have been influenced by the personal experiences of the participants regarding the availability (or lack of availability) of a suitable alternate route in their driving environment.

The results indicate that a large majority of drivers would indeed use accurate information about freeway traffic conditions to plan their trips and to divert to an available arterial street, if they were informed of an

unusual condition on the freeway. The motorists would be more inclined to divert to the arterial street before they entered the freeway than they would after they entered the freeway.

Current Use of Commercial Radio for Route Selection

The results of that part of the questionnaire used to evaluate the current use of commercial radio for real-time driver information during the peak periods are summarized in Table 4. The results show that 57 percent of the participants surveyed indicated that they normally use the traffic and accident reports that are given over the radio stations during the peak periods to plan their trips within the city.

Those who did not use the radio for these reports were asked to give reasons why. A summary of these comments is presented in Table 5. It is interesting to note that, although 43 percent of the sampled participants gave a negative response, about 7 percent would not have the opportunity to use the reports. This percentage includes those respondents who do not have car radios and those who travel on the city streets or ride buses during the peak periods. If this 7 percent were eliminated from the sample, the results show that 62 percent of the participants who have radios and who could benefit from radio reports on freeway conditions currently use the information for trip planning (Table 4). There is indication, based on the comments in Table 5, that this percentage would increase if the information were more accurate and timely.

Potential of Commercial Radio for Effective Systems Design

The data were analyzed to determine the potential of commercial radio as part of an integrated real-time driver communication system.

TABLE 4

DRIVER USE OF CAR RADIO

Question	Response	Respondents (%)
Normally use radio traffic and accident reports for trip planning during peak periods		
Total sample	Yes	57
	No	43
Sample excluding those without car radios and those who drive the city streets or ride the bus during peak periods	Yes	62
	No	38
Normally listen to car radio	Yes	89
	No	11

TABLE 5

COMMENTS OF THOSE WHO INDICATED THAT THEY DO NOT USE TRAFFIC AND ACCIDENT REPORTS GIVEN ON RADIO STATIONS

General Type of Comment	Number That Responded	Percent Of The Total Sample
Dissatisfaction with accuracy and timeliness of reports	55	10.9
Do not listen to or hear the reports	30	5.9
Take only one route to and from work	26	5.2
Do not have a radio	19	3.7
Do not travel freeways during peak flows	15	3.0
Live a short distance from place of work	7	1.4
No congestion on route	7	1.4
Reports do not involve route	5	1.0
Ride bus to and from work	3	0.6
Others	8	1.5
TOTAL	175	34.6

Table 4 shows that 89 percent of the participants normally listen to the car radio. This high majority indicates that communication via this mode does seem to have great potential.

Analysis of the drivers' priorities for methods of communication revealed that there was a definite preference for having real-time freeway information given by means of commercial radio and changeable message signs in comparison to a telephone service or television broadcasts. The preference for the mode of communication was evenly divided between commercial radio and changeable message signs. Forty-five percent of the respondents selected commercial radio as their first choice; an additional 45 percent selected changeable message signs. Telephone and television were not preferred, each having received only 5 percent first choice votes. A summary of the driver priorities is tabulated in Table 6.

The data were further analyzed to determine whether there was consistency in the manner in which the participants ranked these modes. Kendall's Coefficient of Concordance, W, (5), which detects the consistency (or lack of consistency) in ranking ordinal data, was computed. The significance of the coefficient was then tested using the Chi Square, χ^2, statistic. The test does not reveal the degree of preference, but does determine whether the ranking was consistent among the participants and provides a basis for determining the best estimate of the "true" ranking according to consensus based on the R_j values. The results of the analysis are presented in Table 13 and are summarized in Table 6.

The analysis revealed that W was computed to be 0.4944. In addition, the χ^2 value of 642.2 was highly significant at the .01 level. Therefore, it can be concluded that there was consistency in ranking the modes of

TABLE 6

DRIVER PRIORITIES OF MODES FOR
RECEIVING REAL-TIME FREEWAY INFORMATION

Alternative	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking* Points	Standard Deviation
Radio	45	46	7	2	3.4	0.6
Signs	45	36	13	4	3.3	0.8
Telephone	5	11	31	53	1.7	0.8
Television	5	7	49	39	1.8	0.7

*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. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

Kendall's Coefficient of Concordance, W = 0.4944

Chi Square, $\chi^2 = 642.2^{**}$

d.f. = 3

communication among the participants and that the selection of the modes was not random. Based on the values of R_j in Table 13, the order of preference can be said to be as follows:

1) Radio
2) Signs
3) Television
4) Telephone

It must be emphasized that the statistical test does not allow one to measure the relative differences between the choice of modes. The final ordering of preferences was based solely on the R_j values. An examination of these values for radio and signs shows that the differences between them are relatively small. In addition, from Table 6, it is evident that the computed average ranking points for these modes are approximately equal. Therefore, it would be difficult to conclude that radio was considered superior to signs. The results indicate that there does not appear to be any appreciable difference between the preference for radio and the preference for changeable message signs.

To further evaluate the role of commercial radio in the design of a real-time freeway information system, analysis was made to determine the location, relative to the freeway, where information would be most helpful to the motorists. The results of the respondents' rankings of alternate locations are presented in Table 7. Statistical analyses of the data are presented in Table 14 of the Appendix and are summarized in Table 7.

The computed value of W (0.1332) was shown to be highly significant at the .01 level which indicated consistency in the rankings between respondents. Based on the R_j values, the following constitutes the order of preference for locations:

TABLE 7

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME FREEWAY 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 for each 1st choice, 3 points for each 2nd choice, 2 points for each 3rd choice, and 1 point for each 4th choice. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

Kendall's Coefficient of Concordance, W = 0.1332

Chi Square, $\chi^2 = 181.4^{**}$

d.f. = 3

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

The results indicate that motorists prefer to receive information about freeway traffic conditions before they enter the freeway and at locations where decisions can be made with respect to the selection of alternate routes. The above ordering is an indication of the relative preference of the four alternatives. It does not indicate any lack of need for information at any of the locations. It strongly suggests that drivers would prefer to receive freeway traffic information before they enter the freeway, so that appropriate diversion at critical decision points can be made.

These results are consistent with the earlier findings, in that the participants indicated a greater degree of willingness to divert to an available alternate route before they entered the freeway, in comparison to after they have entered. Therefore, the desire for traffic information prior to entering the freeway would be of greater value to them.

This finding is not in agreement with that of Heathington (3), who found that the drivers in Chicago indicated a higher preference for freeway traffic information provided on the freeway than on the arterial streets. The reasons for the discrepancy are not known; however, data relating to the frequency of freeway use for the sample taken in the Chicago area were not available for comparison. It should be noted that 82 percent of the drivers surveyed in Houston and Dallas used the freeway more than five times per week.

Although the above listing represents the ordering of locations based

on averages, the first choice selections were somewhat different. Forty-two percent of the participants felt that the beginning of the trip was the most desirable location in relation to the other alternatives. Thirty-four percent chose to receive information on the major street, 16 percent at the entrance ramp, and 8 percent on the freeway as their first choices.

The distribution of the sample relative to preference for receiving information at the beginning of the trip was of considerable interest. Forty-two percent selected this alternative as their first choice, whereas 40 percent indicated that this alternative was least preferred. These results seem to indicate that approximately half of the freeway drivers would prefer to know the freeway traffic condition before beginning their trips, while the other half find it unnecessary.

To evaluate this contrast, the data of these two groups were analyzed. In addition, data of the groups that selected either radio or signs as the most preferred mode of communication were analyzed to establish whether there were any relationships between the selection of location and the mode of communication. The results are presented in Tables 8, 9, 10 and 11.

The results show that 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.

Analysis of the modes of communication revealed that 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

TABLE 8

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME INFORMATION - PARTICIPANTS WHO PREFERRED RADIO

Alternative	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking* Points	Standard Deviation
On The Freeway	6	11	33	50	1.8	0.8
On The Major Street	32	41	16	11	3.0	0.9
At The Entrance Ramp	10	35	46	9	2.5	0.7
At The Beginning of Trip	52	13	5	30	3.0	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. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

Kendall's Coefficient of Concordance, W = 0.1913

Chi Square, $\chi^2 = 114.7^{**}$

d.f. = 3

TABLE 9

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME INFORMATION - PARTICIPANTS WHO PREFERRED SIGNS

Alternative	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking* Points	Standard Deviation
On The Freeway	12	16	37	35	2.1	0.9
On The Major Street	39	33	22	6	3.1	0.9
At The Entrance Ramp	23	42	32	3	2.9	0.8
At The Beginning of Trip	26	9	9	56	2.1	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. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

Kendall's Coefficient of Concordance, W = 0.1492

Chi Square, $\chi^2 = 94.9^{**}$

d.f. = 3

TABLE 10

DRIVER PRIORITIES FOR MODES OF RECEIVING REAL-TIME INFORMATION - PARTICIPANTS WHO PREFERRED INFORMATION AT THE BEGINNING OF TRIP

Alternative	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking Points*	Standard Deviation
Radio	56	34	9	1	3.5	0.7
Signs	28	44	20	8	3.0	0.9
Telephone	9	14	28	49	1.9	0.9
Television	7	8	43	42	1.9	0.8

*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. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

Kendall's Coefficient of Concordance, W = 0.3950

Chi Square, $\chi^2 = 216.9^{**}$

d.f. = 3

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.

In summary, there seems to be a relationship between the selection of modes and of location. This is not a surprising result. If one were to analyze the location, relative to the freeway, that the participants live or work*, it would appear that there would be a wide variance in the opportunities to divert, and the mode of communication would be important to them. In addition, some people plan the time of departure for their work trips based on information received regarding traffic conditions. The results suggest that the combination of radio and signing would provide for an effective real-time freeway information system.

Houston vs. Dallas Participants

The data were analyzed to determine whether there were any differences in the responses to the questions between the participants from Houston and those from Dallas. There was some speculation that traffic reports given by the radio stations may have been better in one of the cities; thus, the responses by the participants may have been different. The

*Proper data were not available to perform this type of analysis.

results of this subgroup analysis are presented in Figure 2 and Tables 15-20 in the Appendix.

The results revealed that there were no appreciable differences in the responses of the participants between the two cities, with one minor exception. The respondents in Dallas indicated a slightly greater willingness to leave the freeway and divert to available alternate arterial streets both during the peak period (81 percent vs. 72 percent) and off-peak period (73 percent vs. 68 percent).

Discussion of Results

The results of this research suggest that commercial radio, in conjunction with changeable message signs, could play a vital role as part of an effective real-time driver information system for urban freeways. It is clear that motorists would prefer to receive information prior to entering the freeway, and they feel that commercial radio would be an effective way to communicate with them. The majority of motorists have access to radios in their homes, automobiles, and in some cases, at their places of employment. Information would be easily accessible to them without requiring an additional direct expenditure on their part.

The effectiveness of commercial radio will be dependent upon the accuracy and timeliness of the information that is provided. These requirements, of course, are necessary for effective real-time communication regardless of the mode. Based on the results of this study, it is recommended that commercial radio be further developed as an integral part of a real-time driver information system for urban freeways.

CONCLUSIONS

Based on the analysis of a questionnaire survey administered to 505 participants (327 from Houston and 178 from Dallas), the following conclusion is made:

1. Commercial radio could play a vital role as part of an effective real-time traffic information system for urban freeways. This conclusion is based on the following findings:
   a. Motorists expressed a willingness to divert to an alternate arterial street if they had knowledge of an unusual condition on the freeway and provided that a suitable alternate route were available. The motorists would be more inclined to divert before they entered the freeway than they would once on the freeway.
   b. Forty-seven percent of the respondents indicated that they would always use information about freeway traffic conditions to plan their trips if the information were accurate. Another 38 percent responded that they would frequently use the information.
   c. Sixty-two percent of the participants, who had car radios and who could benefit from radio reports of freeway conditions, currently use radio traffic bulletins for trip planning during the peak period. There were indications that this percentage would increase if the information were more accurate and timely.
   d. Eighty-nine percent of the participants indicated that they normally listen to the car radio.

e. The participants ranked their preferences of four modes of communication according to the following order:

1) Radio
2) Signs
3) Television
4) Telephone

The above rankings were based on the R_j values of Kendall's Coefficient of Concordance (5). Further evaluation of the results indicated that there did not appear to be any appreciable difference between the preference for radio and the preference for signs, in spite of the ranking resulting from Kendall's test.

f. Motorists expressed preferences for receiving information about freeway traffic conditions before they enter the freeway and at locations where decisions can be made with respect to the selection of alternate routes. The following represents the consensus of preference based on Kendall's test:

1) On the major street
2) At the entrance ramps
3) At the beginning of trip
4) On the freeway

g. The findings shown in item f are based on average values. Analysis of first choice preferences revealed that 42 percent of the participants considered information at the beginning of the trip to be their highest preference, 34 percent chose to receive information on the major street as their first preference, 16 percent chose the entrance ramps and 8 percent preferred information on the freeway itself.

h. There was a major division in attitudes toward the

preference for traffic information at the beginning of the trip. Forty-two percent selected this location alternative as their first choice, whereas 40 percent indicated that this alternative was least preferred.

i. There appears to be a relationship between the preference of communication mode and the preference for receiving information at the beginning of the trip.

   1) The motorists who selected the beginning of trip as their first choice of location ranked radio as their preferred mode of communication.

   2) The motorists who considered traffic information at the beginning of trip of least value placed a high preference on signs.

   3) The motorists who ranked radio as the most preferred mode of communication placed a high emphasis on receiving information at the beginning of the trip and on the major streets. The preference for these two location alternatives was approximately equal.

   4) The motorists who chose signs as the preferred mode of communication placed high emphasis for traffic information on the major streets and at the entrance ramps. Information at the beginning of the trip and on the freeway were the least preferred alternatives.

j. There did not appear to be any appreciable differences in the responses to the questions between the Houston participants and those in Dallas.

REFERENCES

1. Weinberg, M. I., Deley, N. J. and Schneeberger, R. F. Surveillance Methods and Ways of Communicating with Drivers. NCHRP Report 28, 1966.

2. Fowler, P. A New Look at Traffic Broadcasts. Auto Club News Pictorial. Automobile Club of Southern California, October, 1967.

3. Heathington, K. W., Worrall, R. D., and Hoff, G. D. An Evaluation of Priorities Associated with the Provision of Traffic Information in Real-Time. Paper presented at the Annual Meeting of the Highway Research Board, January, 1970.

4. Dudek, C. L. and Jones, H. B. Real-Time Driver Information Needs for Urban Freeways. Texas Transportation Institute Research Report 139-4, July, 1970.

5. Siegel, S. Nonparametric Statistics. McGraw-Hill Book Co., Inc. New York, 1956.

APPENDIX

TABLE 12

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 12 (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

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 13

KENDALL'S TEST FOR RANKING - MODES OF COMMUNICATION

	Radio		Signs		Telephone		Television		TOTAL	
RANK	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	195	780	198	792	20	800	20	80	433	1732
2	199	597	157	471	47	141	30	90	433	1299
3	32	64	55	110	133	266	213	426	433	866
4	7	7	23	23	233	233	170	170	433	433
R_j		1448		1396		720		766		4330

$\overline{R} = \frac{\Sigma R_j}{N} = 1082.5$

$S = \Sigma(R_j - \overline{R})^2 = 463,451$

$W = \frac{12\ S}{k^2\ (N^3-N)} = 0.4944$

$\chi^2 = k\ (N-1)\ W = 642.2^{**}$

d.f. = 3

TABLE 14

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

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

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

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

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

d.f. = 3

TABLE 15

SUMMARY OF PROBABLE DIVERSION TO AN AVAILABLE MAJOR STREET ASSUMING INFORMATION WAS AVAILABLE - HOUSTON VS. DALLAS PARTICIPANTS

Alternative		Houston (%)	Dallas (%)	All Respondents (%)
Condition:	Peak Period: Information Before Entering Freeway			
	Would Divert	92	92	92
	Would Not Divert	8	8	8
Condition:	Peak Period, Information Given After Entering Freeway			
	Would Divert	72	81	75
	Would Not Divert	28	19	25
Condition:	Off Peak, Information Given After Entering Freeway			
	Would Divert	68	73	70
	Would Not Divert	32	27	30

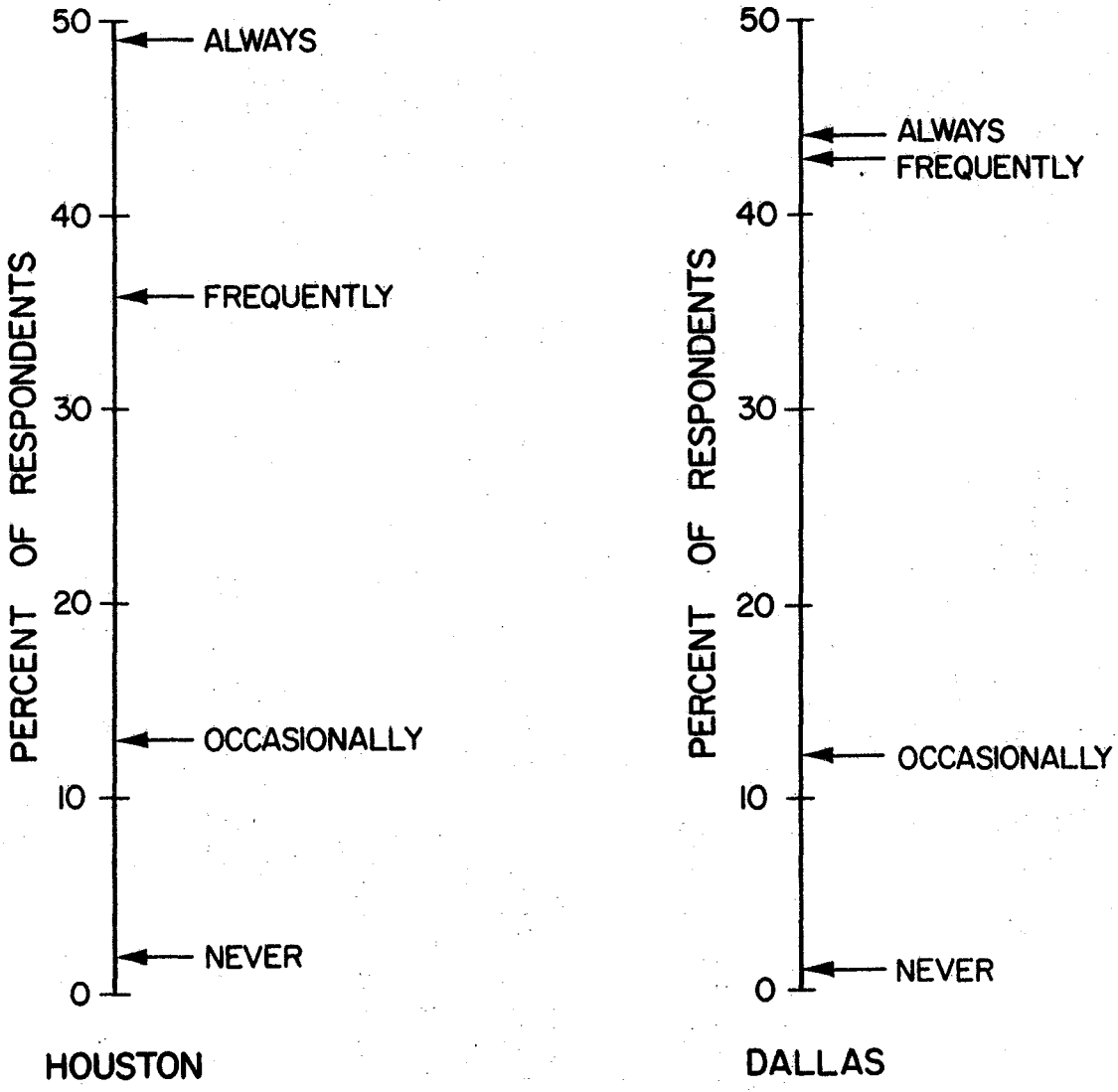

FIGURE 2- DRIVER USE OF REAL-TIME FREEWAY INFORMATION — HOUSTON VS. DALLAS

TABLE 16

DRIVER USE OF CAR RADIO -
HOUSTON VS. DALLAS PARTICIPANTS

Question	Response	Houston (%)	Dallas (%)	Respondents (%)
Normally use radio traffic and accident reports for trip planning during peak periods				
Total sample	Yes	55	61	57
	No	45	39	43
Sample excluding those without car radios and those who drive the city streets or ride the bus during peak periods	Yes	59	65	62
	No	41	35	38
Normally listen to car radio	Yes	89	89	89
	No	11	11	11

TABLE 17

DRIVER PRIORITIES OF MODES FOR RECEIVING REAL-TIME INFORMATION - HOUSTON VS. DALLAS PARTICIPANTS

Alternative	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking Points*	Standard Deviation
I. Houston						
Radio	42	47	9	2	3.3	0.7
Signs	48	35	12	5	3.3	0.8
Telephone	5	11	29	55	1.7	0.8
Television	5	7	50	38	1.9	0.7
II. Dallas						
Radio	51	43	5	1	3.5	0.6
Signs	42	40	13	5	3.2	0.8
Telephone	3	11	34	52	1.7	0.8
Television	4	6	48	42	1.8	0.7
III. Total						
Radio	45	46	7	2	3.4	0.6
Signs	45	36	13	4	3.3	0.8
Telephone	5	11	31	53	1.7	0.8
Television	5	7	49	39	1.8	0.7

*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. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

TABLE 18

SUMMARY OF STATISTICAL TESTS OF THE CONSISTENCY IN RANKING MODES OF COMMUNICATION

	Kendall's Coefficient, W	Chi Square Value*	Significant at .01 Level
Houston	0.4721	406.5	Yes
Dallas	0.5433	238.0	Yes
Total	0.4944	642.2	Yes

*d.f. = 3

TABLE 19

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME INFORMATION - HOUSTON VS. DALLAS PARTICIPANTS

	Alternative	1st Choice (%)	2nd Choice (%)	3rd Choice (%)	4th Choice (%)	Average Ranking Points*	Standard Deviation
I.	Houston						
	On The Freeway	9	15	31	45	3.1	0.9
	On The Major Street	34	39	19	9	2.0	0.9
	At The Entrance Ramps	15	34	44	5	2.4	0.8
	At The Beginning of Trip	42	12	5	41	2.4	1.3
II.	Dallas						
	On The Freeway	8	11	40	45	3.1	0.8
	On The Major Street	37	40	17	9	1.9	0.9
	At The Entrance Ramps	16	42	36	9	2.3	0.8
	At The Beginning of Trip	42	10	10	40	2.4	1.3
III.	Total						
	On The Freeway	8	14	34	44	3.1	0.9
	On The Major Street	34	39	18	9	2.0	0.9
	At The Entrance Ramps	16	36	41	7	2.3	0.8
	At The Beginning of Trip	42	11	7	40	2.4	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. Minimum Possible Mean = 1.0; Maximum Possible Mean = 4.0.

TABLE 20

SUMMARY OF STATISTICAL TESTS OF THE CONSISTENCY IN RANKING LOCATIONS FOR INFORMATION

	Kendall's Coefficient, W	Chi Square Value*	Significant at .01 Level
Houston	0.1244	113.1	Yes
Dallas	0.1519	68.81	Yes
Total	0.1332	181.4	Yes

*d.f. = 3