EVALUATION OF COMMERCIAL RADIO FOR REAL-TIME DRIVER COMMUNICATIONS ON URBAN FREEWAYS

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Driver preferences were measured through a questionnaire survey to evaluate the potential of commercial radio for providing real-time freeway traffic information to drivers in urban areas. In addition, traffic reports given by 3 radio stations in the Houston area were monitored to evaluate the reliability, accuracy, and timeliness of current traffic broadcasts. The results of the study suggest that commercial radio could play an important role as part of an effective real-time traffic information system for urban freeway drivers. However, traffic reports as currently broadcast by the 3 radio stations monitored in Houston would not be completely satisfactory for the system being considered. Improvements in the reliability and timeliness of the traffic information provided would be necessary.

•THE Texas Transportation Institute and the Texas Highway Department, in cooperation with the U.S. Department of Transportation, are conducting a research project on freeway control and information systems. This project is an outgrowth of previous research on the Gulf Freeway in Houston that culminated in an operational freeway ramp-control system (1). One objective of the project is to develop a real-time traffic information system for an urban freeway corridor. Several designs will be evaluated for the development of an effective system.

One method of transmitting real-time traffic information is through the use of commercial radio. To obtain a better understanding of the use of commercial radio for real-time driver communications on urban freeways, driver use of and attitudes toward radio broadcasts were evaluated. In addition, the procedures used by 3 Houston radio stations in broadcasting freeway traffic information and the reliability, accuracy, and timeliness of traffic information currently being broadcast were evaluated.

PROJECT APPROACH

A comprehensive questionnaire designed by a multidisciplinary team was administered to 505 employees of several organizations in Houston and Dallas to obtain data for the design of a driver-information system. A portion of the questionnaire was designed to provide specific inputs for the study of the application of commercial radio to freeway communications. Specific details of the questionnaire survey have been documented in the literature (2, 3).

The Gulf Freeway in Houston was selected as the study site to evaluate traffic information currently being broadcast because of the existing research and surveillance facilities. The Gulf Freeway surveillance and control system includes entrance ramp signals, a digital process control computer, and a 14-camera closed-circuit television surveillance system. Since the installation of the television system, the Houston Police Department has maintained a patrolman and a base station police radio in the control center to detect and report traffic incidents that occur on the study section of the freeway. Information relating to the occurrence of incidents is also recorded on log

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sheets. This surveillance provided the opportunity to evaluate the responses of radio stations in the Houston area to the incidents on the freeway.

For the purposes of this study, the broadcasts of 3 local radio stations that provided peak-period traffic bulletins were monitored with magnetic voice recorders. The tapes were later transcribed, and traffic information relating to the Gulf Freeway study section was recorded on prepared data forms. The following information was noted:

1. The station that broadcast information about the incident;
2. The extent of the information broadcast;
3. The time of the broadcast (or broadcasts) relating to the specific incident; and
4. The station that broadcast information when the incident had been cleared or removed.

The data forms were then compared to the raw data recorded by the television monitors.

To evaluate the provision of traffic information to motorists, personnel from the 3 radio stations were interviewed by representatives of the Texas Transportation Institute and the Texas Highway Department. A basic set of questions was prepared to make the interviews as consistent as possible. In addition, an interview was held with law enforcement personnel in the dispatcher's office of the Houston Police Department.

RESULTS OF SURVEY

The results of the comprehensive questionnaire survey relevant to this study and those reported elsewhere (2, 3) have shown that a large majority of the participants indicated that they would use accurate real-time freeway traffic information to plan their trips. The respondents also indicated that they would react to real-time information about freeway conditions by rerouting to a suitable alternate route when it is known to be available. The majority prefer to use the alternate route only to bypass congested areas on the freeway and to return to the freeway as soon as possible. In addition, they would be more inclined to divert to an alternate route before reaching the freeway than to change when on the freeway.

Current Use of Commercial Radio for Route Selection

The results of the part of the questionnaire used to evaluate the current use of commerical radio to provide real-time driver information are given in Table 1. 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 they did not. A summary of these comments is given in Table 2. 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 (3.7 percent) and those who do not travel on the city streets (3.0 percent) or ride buses during the peak periods (0.6 percent). If this 7 percent were eliminated from the sample, the results show that 62

TABLE 1

DRIVER USE OF CAR RADIO

Question	Response	Respondents (percent)
Do you normally use radio traffic and accident reports for trip planning during peak periods?		
All respondents	Yes	57
	No	43
Respondents excluded who do not have car radios, who do not drive during rush hours, and who ride the bus	Yes	62
	No	38
Do you normally listen to car radio?	Yes	89
	No	11

TABLE 2

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

Comment	Respondents	
	Number	Percent
Dissatisfied 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
Have no congestion on route	7	1.4
Travel route not involved in reports	5	1.0
Ride bus to and from work	3	0.6
Other	8	1.5
Total	175	34.6

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 1). There is indication, based on the comments given in Table 2, 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. Data given in Table 1 show that 89 percent of the participants normally listen to the car radio. Such a high majority indicates that this mode would seem to have great potential for providing real-time traffic information to the driver.

Analysis of the drivers' priorities for methods of communication revealed that there was a definite preference for receiving real-time freeway information by means of commercial radio and changeable message signs as opposed to a telephone service or television. The preference for the mode of communication was evenly divided between commercial radio and changeable message signs. Forty-five percent of the respondents selected changeable message signs. Telephone and television were not preferred, each having received only 5 percent of the first-choice votes. A summary of the driver priorities is given in Table 3.

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, which detects the consistency (or lack of consistency) in the ranking of ordinal data, was computed (4). The significance of the coefficient was then tested by using the χ^2 statistic. The test does not reveal the degree of preference, but it does determine whether the ranking was consistent among the participants and provides a

TABLE 3

DRIVER PRIORITIES OF MODES FOR RECEIVING REAL-TIME FREEWAY INFORMATION

Mode	First Choice (percent)	Second Choice (percent)	Third Choice (percent)	Fourth Choice (percent)	Average Ranking[a] 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

[a]Based on assigning 4 points for each first choice, 3 points for each second choice, 2 points for each third choice, and 1 point for each fourth choice. Minimum mean = 1.0; maximum mean = 4.0.

TABLE 4

KENDALL'S TEST FOR RANKING MODES OF COMMUNICATION

Rank	Radio		Signs		Telephone		Television		Total	
	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	195	780	198	792	20	800	20	80	433	1,732
2	199	597	157	471	47	141	30	90	433	1,299
3	32	64	55	110	133	266	213	426	433	866
4	7	7	23	23	233	233	170	170	433	433
R_j		1,448		1,396		720		766		4,330

Note: $\bar{R} = \Sigma R_j/N = 1{,}082.5$; $S = \Sigma(R_j - \bar{R})^2 = 463{,}451$; $W = (12S)/[k^2(N^3-N)] = 0.4944$; $X^2 = k(N-1)W = 642.2$ (significant at 0.01 level); and degrees of freedom = 3.

basis for determining the best estimate of the true ranking based on the R_j values. The results are given in Table 4.

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 0.01 level. Therefore, it can be concluded that there was consistency in the ranking of the communication modes among the participants and that the selection of the modes was not random. Based on the values of R_j given in Table 4, the order of preference is as follows: choice 1, radio; choice 2, signs; choice 3, television; and choice 4, telephone.

It must be emphasized that the statistical test does not allow one to measure the relative differences among the choice of modes. The final ordering of preferences was based solely on the R_j values of Kendall's test. An examination of these values for radio and signs showed that the differences between them were relatively small. In addition, from the data given in Table 3, it is evident that the computed average ranking points for these modes are approximately equal. 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' ranking of alternate locations are given in Table 5. Statistical analyses of the data are given in Table 6.

The computed value of W (0.1332) was shown to be highly significant at the 0.01 level, which indicated consistency in the rankings among respondents. Based on Kendall's test, the following is the order of preference for the following locations: choice 1, on the major street; choice 2, at the entrance ramp; choice 3, at the beginning of the trip; and choice 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 preceding ordering is an

TABLE 5

DRIVER PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME FREEWAY INFORMATION

Location	First Choice (percent)	Second Choice (percent)	Third Choice (percent)	Fourth Choice (percent)	Average Ranking Points[a]	Standard Deviation
On freeway	8	14	34	44	1.9	0.9
On major street	34	39	18	9	3.0	0.9
At entrance ramps	16	36	41	7	2.7	0.8
At beginning of trip	42	11	7	40	2.6	1.3

[a]Based on assigning 4 points for each first choice, 3 points for each second choice, 2 points for each third choice, and 1 point for each fourth choice. Minimum mean = 1.0; maximum mean = 4.0.

TABLE 6

KENDALL'S TEST FOR RANKING LOCATIONS OF COMMUNICATION

Rank	On Freeway		On Major Streets		At Entrance Ramps		At Beginning of Trip		Total	
	Number	Points	Number	Points	Number	Points	Number	Points	Number	Points
1	38	152	156	624	71	284	189	756	454	1,816
2	62	186	177	531	165	495	50	150	454	1,362
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		1,358		1,185		1,153		4,540

Note: $\bar{R} = \Sigma R_j/N = 1,135$; $S = \Sigma(R_j - \bar{R})^2 = 137,234$; $W = (12S)/[k^2(N^3 - N)] = 0.1332$; $X^2 = k(N - 1)W = 181.4$ (significant at 0.01 level); and degrees of freedom = 3.

indication of the relative preference of the 4 alternatives. It does not indicate any lack of need for information at any of the locations. The ordering 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.

Although the preceding 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 as their first choice, 16 percent selected the entrance ramp, and 8 percent preferred information on the freeway.

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 indicate that approximately half of the freeway drivers prefer to know the freeway traffic condition before beginning their trips, while the other half find it unnecessary.

This contrast was evaluated by analyzing the data from these 2 groups. In addition, data of the groups that selected either radio or signs as the preferred mode of communication were analyzed to establish any relationships between the selection of location and the mode of communication. The results are given in Tables 7 and 8. 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 the provision of information at the beginning of the trip to be of least value selected signs as their first choice of communication.

Analysis of the communication modes 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 of greatest value. The analysis also revealed that those who chose signs as the preferred mode of communication placed a

TABLE 7

PRIORITIES OF LOCATIONS FOR RECEIVING REAL-TIME INFORMATION

Participant	Location	First Choice (percent)	Second Choice (percent)	Third Choice (percent)	Fourth Choice (percent)	Average Ranking Points[a]	Standard Deviation
Prefer radio	On freeway	6	11	33	50	1.8	0.8
	On major street	32	41	16	11	3.0	0.9
	At entrance ramp	10	35	46	9	2.5	0.7
	At beginning of trip	52	13	5	30	3.0	1.3
Prefer signs	On freeway	12	16	37	35	2.1	0.9
	On major street	39	33	22	6	3.1	0.9
	At entrance ramp	23	42	32	3	2.9	0.8
	At beginning of trip	26	9	9	56	2.1	1.3

[a]Based on assigning 4 points for each first choice, 3 points for each second choice, 2 points for each third choice, and 1 point for each fourth choice. Minimum mean = 1.0; maximum mean = 4.0.

TABLE 8

PRIORITIES FOR MODES OF RECEIVING REAL-TIME INFORMATION

Participant	Mode	First Choice (percent)	Second Choice (percent)	Third Choice (percent)	Fourth Choice (percent)	Average Ranking Points[a]	Standard Deviation
Prefer information at beginning of trip	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
Do not prefer information at beginning of trip	Radio	34	60	4	2	3.3	0.6
	Signs	64	28	6	2	3.6	0.6
	Telephone	1	7	32	60	1.5	0.6
	Television	1	5	58	36	1.8	0.6

[a]Based on assigning 4 points for each first choice, 3 points for each second choice, 2 points for each third choice, and 1 point for each fourth choice. Minimum mean =1.0; maximum mean = 4.0.

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 least preferred.

The results of the study show an expected relationship between the selection of mode and the selection of location. If one were to analyze the locations where the participants live or work in relationship to the freeway, there undoubtedly would be a wide variance in the opportunities to divert, and the selection of communication mode would be influenced by these opportunities. In addition, some people plan their trips for work based on information received while listening to their radios at their homes. The results suggest that the combination of radio and signing would be desirable for an effective real-time freeway information system.

Houston Versus Dallas Participants

The data were analyzed to determine whether there were any differences between the responses of the Houston participants and those from the Dallas participants. 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 results revealed that there were no appreciable differences in the responses from participants in the 2 cities.

BROADCAST PROCEDURES

Basically, all 3 stations that were monitored in Houston rely on traffic information provided by the Houston Police Department, although there are slight variations as to how the information is placed on the air. Telephone calls requesting the services of the police and calls from other police officers in the field are directed to the dispatch office. Those calls received relating to traffic accidents or other situations that cause traffic congestion during the peak periods are noted, and the information is given to an officer who has the responsibility of relaying this to the radio stations. It is important to note that information received by the police dispatcher is the only information that is relayed to the radio stations by the police. Consequently, traffic incidents not requiring police aid or investigation would not normally be available for broadcast by the radio stations.

A schematic of the normal broadcast process is shown in Figure 1. Two basic methods of obtaining traffic information are utilized by the radio stations in Houston. One method involves telephoning the officer who has the responsibility of relaying traffic information that he has received. The radio station personnel generally telephone whenever the station is ready to broadcast the information.

In the second method, the police officer takes the initiative. When the officer has recorded a sufficient number of incidents, he signals the radio stations by pressing a button located at the base of a microphone. Exactly 1 min from this signal, the officer broadcasts the available information to the radio station. Information is given at approximately ½-hour intervals. However, when a major incident occurs, the reports

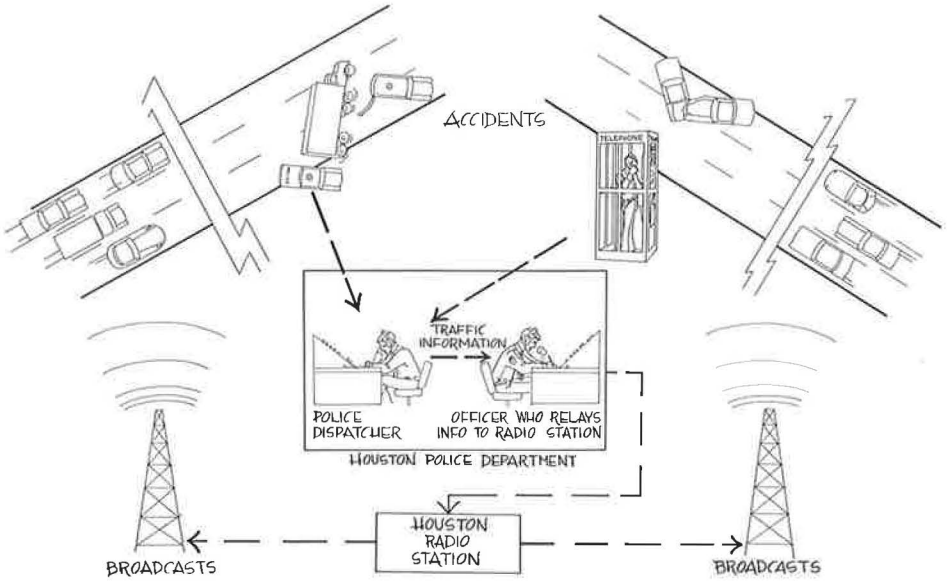

Figure 1. Schematic of traffic information transfer.

may be given at more frequent intervals. Four radio stations in Houston use this method, whereas the other stations telephone the officer directly.

The radio stations then take 1 of 3 actions. Some stations broadcast the information live as it is being received. Others record the information and then play the recorded tape on the air as soon as a convenient opportunity arises. Other stations utilize the traffic information that they receive, but the radio announcer himself makes the broadcast. The 3 radio stations that were monitored use the following procedures:

1. Station A calls the officer when it is ready to broadcast traffic information. The information is taped and played on the air as soon as possible.
2. Station B calls the officer when it is ready to broadcast but uses its own personnel to broadcast on the air.
3. Station C uses procedures comparable to station A.

Traffic Broadcasts

A summary of the traffic reports by the 3 radio stations is given in Table 9. A total of 214 incidents were observed within the Gulf Freeway surveillance area during the study period and included 110 accidents and 104 stalls. The analysis revealed that a relatively low percentage of the observed accidents was actually broadcast. Analysis revealed that 52 percent of the accidents were not reported by any of the stations, 24 percent of the accidents were reported by only 1 station, 17 percent of the accidents were reported by 2 stations, and 7 percent of the accidents were reported by 3 stations.

TABLE 9

TRAFFIC REPORTS OF INCIDENTS

Station	Accidents Reported		Stalls Reported	
	Number	Percent[a]	Number	Percent[b]
A	21	19	3	3
B	29	26	0	0
C	38	35	0	0

[a]Number of accidents observed = 110.
[b]Number of stalls observed = 104.

Although the effects of stalled vehicles during the peak periods could be as adverse as some of the accidents, stalled vehicles were very rarely reported by the monitored radio stations (only 3 reports of 104 stalls). The average duration of a stall was about 10 min, which can be compared to the 13-min duration of an accident on the roadway.

Relative Time of Radio Reports

In addition to the probability of incident reports by the radio stations, it was also important to determine the time of the reports relative to the occurrence of the incidents. The ideal situation would be that the radio stations report the incident immediately after it occurs. If the motorist is informed as early as possible, he is afforded more decision time in which to respond to the information and to choose an alternate route if necessary.

TABLE 10

SUMMARY OF REPORTS OF ACCIDENTS BY STATIONS

Station	Percent of Accidents Reported	Average Time to Report Accident (min)	Range of Report Times (min)	Average Number of Broadcasts per Accident Reported
A	19	21.3	8 to 44	1.3
B	26	24.5	1 to 98	1.2
C	35	26.9	3 to 58	1.3

A summary of the reports by the 3 radio stations is given in Table 10. The earliest report time was 1 min, whereas the latest time of the initial broadcast was 98 min. The average number of broadcasts by the stations per reported accident was about 1.3.

Results of the accident reports, with respect to the duration of accidents on the roadway for stations A, B, and C, are given in Table 11. The results indicate that there is no relationship between the duration of accidents and the response time of the radio stations to broadcast the information. There was a wide variability in the response time of each radio station.

The delay by the radio stations to report freeway traffic accidents appears to be due to 2 major reasons. The first is the delay involved between the time the police dispatcher's office receives the information and the time this information is relayed to the radio stations. Based on the interviews with the radio stations and the Police Department personnel, it appears that a delay of $\frac{1}{2}$ hour is not uncommon. The other major reason is that a station transmits reports when its normal scheduling permits, and often this increases the delay.

Accuracy and Reliability of Radio Reports

An analysis of the locations of incidents reported by the radio stations and the locations observed by the surveillance center revealed the following: Radio reports of traffic incidents were generally correct as to location; little information was broadcast that indicated the length of freeway affected by an incident; and no radio reports were monitored that indicate whether an accident that was previously reported had been cleared.

TABLE 11

REPORTS OF ACCIDENTS BY STATIONS A, B, AND C

Station	Duration of Accidents on Roadway (min)	Number of Accidents	Number of Accidents Reported by Station	Average Time to Report Accident (min)	Standard Deviation (min)	Range of Report Times (min)	Average Number of Reports for Same Accident	Average Time Between Additional Reports (min)
A	≤4	29	4	23	7.6	15 to 30	2.0	18
	5 to 8	24	4	26	16.6	10 to 44	1.7	16
	9 to 12	12	4	19	9.3	11 to 31	1.0	–
	13 to 16	12	2	15	9.9	8 to 22	1.5	33
	17 to 55	33	7	21	9.7	9 to 33	1.3	38
B	≤4	29	4	15	7.4	9 to 26	1.0	–
	5 to 8	24	4	25	10.1	17 to 40	1.0	–
	9 to 12	12	4	31	14.3	13 to 48	1.0	–
	13 to 16	12	7	22	12.2	6 to 45	1.0	–
	17 to 55	33	10	27	26.9	1 to 98	1.2	38
C	≤4	29	5	23	9.7	10 to 34	1.4	13
	5 to 8	24	8	29	16.8	9 to 58	1.3	45
	9 to 12	12	6	21	10.4	3 to 34	1.0	–
	13 to 16	12	5	31	14.3	13 to 49	1.4	26
	17 to 55	33	14	28	13.4	8 to 40	1.4	17

SUMMARY OF FINDINGS

The results of this study suggest that commercial radio could play an important role as part of an effective real-time traffic information system for urban freeway drivers. However, traffic reports as currently broadcast by the 3 radio stations in Houston would not be completely satisfactory for the system being considered. Improvements in the reliability and timeliness of the traffic information provided would be necessary. More specifically, the following findings may be drawn from the study:

1. Sixty-two percent of the survey participants, who have 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.
2. Eighty-nine percent of the participants said they normally listen to car radios.
3. The participants ranked their preferences for 4 modes of communication as being radio, signs, television, and telephone. These rankings were based on the R_j values of Kendall's coefficient of concordance (4). 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 changeable message signs, in spite of the ranking resulting from Kendall's test.
4. Motorists expressed preferences for receiving information about freeway traffic conditions before entering 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: on the major street, at the entrance ramps, at the beginning of trip, and on the freeway.
5. The findings shown in item 4 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.
6. Of the 110 observed accidents on the study section of the Gulf Freeway, 52 percent were not reported by any of the stations. In addition, 24 percent were reported by 1 station, 17 percent by 2 stations, and 7 percent by all 3 stations.
7. Only 3 of the 104 stalled vehicles observed were reported by the radio stations. The average duration of the stalls was about 10 min, in comparison to 13 min for the vehicles involved in accidents.
8. The average time to report an accident after it was observed was 21.3 min for station A, 24.5 min for station B, and 26.9 min for station C.
9. No radio reports were monitored that indicated whether an accident, previously reported, had been cleared.
10. Little information was broadcast that indicated the length of freeway affected by an incident.
11. Radio reports of traffic incidents were generally correct as to location.

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