A COMPARISON OF SELECTED TRAFFIC INFORMATION DEVICES

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This study evaluates various traffic information devices with respect to their preference rating by drivers and to the response to each device. A total of 187 respondents were interviewed in groups ranging from 6 to 55. The 6 alternates that were offered to the respondents for preference rating were a symbolic expressway map sign with colored arrows showing traffic conditions, symbolic expressway and arterial street map sign with colored arrows showing traffic conditions, changeable-message lamp matrix sign, roadside radio transmitter, commercial radio traffic broadcast, and experience and driving background. The respondents preferred the lamp matrix sign, the symbolic maps, the radio system, and experience, in that order. The respondents were asked to make a diversion decision based on traffic information received from each of the devices. Information concerning 6 different levels of congestion was presented on the lamp matrix sign, the symbolic map, the roadside radio, and the commercial radio traffic broadcast. For each device, diversion increased as congestion increased, except that the diversion proportion for the symbolic map at one congestion level deviated sharply from an otherwise logical trend. The results show that the respondents preferred visual devices over vocal devices and, for the sample, the differences in diversion response between devices were significant but small in a practical sense.

•DURING the past few years, the motoring public has been led to believe that the major breakthrough necessary to automate their driving is just around the corner. The engineers responsible for operating the highway system would like to believe that this is true. However, it appears that a more realistic time schedule will include a lengthy research program followed by an equally lengthy implementation program. This time schedule must include not only all the necessary research and hardware production time but also the effort necessary to motivate the drivers to buy and use this improvement.

Although current research concerning automatic control of vehicles has produced some significant results, much more work remains to be completed before a safe, economical, and operationally satisfactory control system can be mass produced (1). The automobile driver in the United States has never enthusiastically relinquished any of the independence he enjoys in operating his vehicle. For example, he continues to drive in urban areas where in many cases the trip could be completed more economically and with little time differential by mass transit. To be successful, the automated highway will require a wholesale change in values of drivers.

BACKGROUND

While waiting for the potentially more efficient automated highway to become a reality, the highway engineer has coped with the astounding growth in traffic by imple-

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menting changes in the highway system. Some of these changes have increased the highway system's capacity by providing more and better designed roadways. Other changes have attempted to utilize existing roadways more efficiently. This class of changes has included more sophisticated traffic signal systems, better signing, freeway surveillance and control systems, and experimentation in electronic route guidance systems.

One potential improvement, furnishing the motorist with accurate and up-to-date traffic information, has been the subject of only a limited amount of study. Assuming that travel time plays an important part in the driver's selection of one route from a number of alternates, timely and accurate traffic information may help the driver to select the route that not only has an acceptable travel time but also improves the efficiency of the highway system.

The implementation of any type of transportation improvement should be predicated on affirmative answers to three questions:

1. Will this improvement satisfy a current or projected need?
2. Is the technology capable of supporting this improvement?
3. At the indicated level of expenditure, do the positive results of this improvement outweigh any negative results?

Is There a Need?

The driver's awareness of the need for more or better information to assist him in his driving task has been demonstrated in a number of earlier studies. Heathington tested 782 Chicago area drivers to determine what priorities they gave to improvements that could be made to urban freeways (2). The top three choices were:

1. Better repair of pavement damages such as holes and bumps;
2. Increased enforcement of regulations concerning shoulder riding, lane changing, and driving speed (minimum and maximum); and
3. Provision of signs that can be electronically changed to furnish information about traffic conditions on the expressway ahead.

In the study done by Covault and Bowes on the Kentucky Toll Road, motorists were given information by radio concerning conditions on the roadway ahead (3). A large majority (90 percent) considered the combination of radio and signs preferable to signs alone, particularly when unusual conditions—accidents, maintenance operations, inclement weather, detours, etc.—were encountered. Of the sample, 75 percent would pay over $15 for such a radio, 48 percent over $30, and 25 percent over $50. Only 8 percent would not purchase such a radio.

A recent inventory of attitudes toward transportation by McMillan and Assael found that 62 percent of their sample would like to see the same amount or more money spent on improved traffic signals and signing (4). This ranked fourth among eleven suggested transportation improvements.

One of the outputs of the experimentation in electronic route guidance was a market research study conducted by Eberhard (5). The study compared an in-car route guidance display with conventional signing. A very high proportion (85 percent) of the respondents thought such a system better than the conventional signs. The cost of such a system was estimated at $95 by the respondents. They felt primary use would occur on highways connecting suburban areas with the central business district.

These studies confirm the suspicion that drivers are somewhat dissatisfied with the current method of providing both traffic and routing information. Even recognizing that there is some personal cost included, most drivers prefer to receive a higher level of information than they are now getting.

Most large cities have some form of radio traffic broadcasts, usually consisting of a combination of information from a traffic center and from mobile observers, either airborne or in cars. Because almost all of these broadcasts are commercially sponsored, it would follow that the sponsors consider their expenditure to be offset by the goodwill accruing to them as a result of the broadcasts. In fact, in the Chicago area, some of the broadcasts are sponsored by the commuter railroads. The interest of the sponsors may be considered to be a reflection of the motorists' desire for more traffic information.

Those studies conducted to date and the apparent commercial success of radio traffic broadcasts point out an apparent deficiency of traffic information from the motorist's viewpoint.

Can It Be Done?

The collection of the base of information necessary to support a real-time traffic information system is well within the ability of current technology. As traffic control systems have become more sophisticated, the amount of traffic information collected at a central control point has increased.

An example of this is the Wichita Falls, Texas, computerized traffic control installation (6). The system uses a digital computer to control 77 signalized intersections. The primary objective is to reduce delay and stops at these intersections. The control scheme is based on data acquired from 51 vehicle detectors at 26 different locations. For each detector, the computer monitors (a) the number of vehicles detected; (b) the number of vehicles required to stop; (c) the total stopped delay (vehicle-seconds); (d) the average delay per vehicle; and (e) the probability that a vehicle will be stopped. This type of digital computer-controlled traffic signal system will become more popular as traffic engineers gain familiarity with the resulting increase in capability and flexibility.

As with computerized traffic control systems, the use of freeway surveillance and ramp control systems is becoming more prevalent. Current operational installations in Chicago, Detroit, and Houston will soon be joined by systems in Los Angeles, Boston, and other large cities. Because the successful operation of such a system is directly dependent on the collection and analysis of freeway traffic flow data, this information can become available for motorists to use to select their route (7).

The analysis of the data is normally carried out by a digital computer. When properly programmed, the computer without any intervention can extract the pertinent information from the data and prepare it for presentation to the public with little if any time delay.

The limits of technology do not pose a critical problem in determining how the information is presented. Many presentation techniques are technologically sound and could be implemented at once. The information could be presented to the driver either in his car or outside of his car and could be either oral or visual. Although oral forms will probably be restricted to radio broadcasts of some type, visual forms can be signs outside of the car or a heads-up display inside the car (8).

Although it has so far been a matter of personal opinion and conjecture as to which technique might be the most effective, the ability of the technology to support both data collection and information presentation cannot be a serious deterrent to further prosecution of the development of a traffic information system.

What Might Such a System Do?

In reviewing past research into the effect that an increased level of information has on traffic movement, one should recall that each study was of a particular hardware configuration. The results of these studies reflect the reaction of the driver to the hardware used as well as his reaction to the information presented by the hardware.

With some possible exceptions, no study has directly addressed the problem of the effect of traffic information on route selection. One exception was an inconclusive evaluation by the author of the effect of color-coded changeable-message displays on selection of the best ramp at which to enter an expressway (9). In another study, Heathington found that drivers diverted from their normal route 23 percent of the time when the traffic was heavy (2). The diversion increases somewhat to 30 percent if the driver has heard a radio report of an accident on his normal route.

Other studies have measured the relationship between driver response and information through the use of such parameters as speeds and lane changing. Covault and Bowes found that a roadside radio message stating that an accident had occurred ahead on the left caused a speed decrease of 5 to 8 mph and significant shift of traffic to the right (3). Other messages concerning shoulder maintenance and grass cutting caused a decrease in speed of up to 10 mph but no significant change in lateral placement.

The use of roadside radio as a route guidance technique has also been studied (10). The additional information provided caused the driver to enter the deceleration lane of a designated exit ramp at an earlier point and to make the diverging maneuver at a higher speed.

The use of lane control signals and advisory speed signs on the Lodge Expressway were examined by Wattleworth and Wallace (11). The study considered the use of these devices during both peak and off-peak conditions. During the off-peak, the lane control signals had some significant but small benefits in total travel time and lateral placement. The use of the changeable speed-limit signs during the off-peak produced negligible benefits. The use of these devices during the peak period was judged to have produced essentially no effect.

A series of blank-out signs indicating the closure of entrance ramps was tested to determine their ability to divert entrance ramp traffic. These signs were mounted at all approaches to the ramps under study. They were remotely controlled to indicate that the ramp was closed when traffic conditions warranted. No other device was used to close the ramps. About 25 percent of the normal entrance ramp traffic was diverted during the time these signs were on. The most diversion took place at those ramps where good alternates were available. Also, the entrance ramp motorist could see the freeway from the frontage road before he was committed to using it, and some diversion could be attributed to observation rather than to reaction to the sign.

From these studies it is evident that without further research a reliable estimate of the diversion or traffic flow improvements resulting from a real-time traffic information system could not be made.

This brief look at the previous examinations of traffic information systems has provided some answers to the questions posed for consideration of a transportation improvement. The motorist is dissatisfied with the present level and quality of traffic and routing information that he receives. In particular, information about urban freeway traffic seems to be a primary concern. The technological capability exists to provide both route and traffic information. The major decision to be made concerns the technique of presentation. Estimating the results of a driver information system cannot be done without additional study. The technique chosen to present the information will in part determine the effectiveness of the system. It is the intent of this paper to provide information to be used in making the selection of the system that offers the greatest chance of success.

CONDUCT OF THE RESEARCH

The inconclusive results of an earlier effort to divert potential entrance ramp traffic from congested expressways created a feeling that perhaps the installation of the informational sign was premature (9). A more reasonable but more lengthy course of action would have been to first examine the various techniques that might be used to present traffic information to ascertain which techniques are the most feasible and which offered an acceptable potential for success.

Motorists headed for an expressway entrance ramp can benefit from diversion under two sets of circumstances. One is when the expressway has become severely congested as a result of either an incident or an excess of ramp traffic attempting to use the expressway. Incidents are quite common, with about three peak periods out of four having reduced capacity due to an incident (12).

The other occasion when the ramp user might benefit from diversion will occur as the result of the operation of a ramp control system. Such a system can result in queuing behind ramp metering devices. If the queue delay is longer than the increased travel time on an alternate route, the motorist will benefit by diverting.

Diversion can also increase the efficiency of the roadway network. A ramp control system must cause some diversion in order to accomplish its purpose. The accumulation of travel time benefits on the expressway can be offset by ramp delays if no diversion takes place. Other delays can occur if the ramp queues extend into adjacent intersections and traffic other than that directly involved with the operation of the freeway is delayed. This delay is associated with the degraded operation of the intersection, and the amount of time lost can increase very rapidly.

In order to benefit the roadway system, diversion must be relied on to keep ramp delays from overriding expressway benefits and must keep ramp queues from interfering with arterial street traffic.

The Chicago Area Expressway Surveillance Project is rapidly expanding its system of freeway surveillance and ramp control. An increased length of freeway under surveillance and an increase in the number of controlled ramps have provided both the means and the necessity to become involved in traffic information research.

Because the project already had the data collection and analysis capability, the selection of a presentation device was the first critical decision to be made. This decision could not be made without further information about the motorist's opinion of the various devices under consideration.

Development of Survey Questionnaire

A questionnaire was developed that would determine how well a motorist liked each candidate device and how strongly and correctly he responded to each device. The questionnaire was divided into six sections. Some of the sections are not germane to this particular research but were included to provide data on some other problems of current interest.

The first section compared the driver's ability to identify expressways in Chicago by name and number. The second section tested some of the hypotheses used in the design of an earlier informational sign developed by the Chicago Area Expressway Surveillance Project (9). An explanation of how the symbols used on that sign correlated with traffic conditions constituted the third section.

Sections four and five are being used as the basis of this report. Section four of the questionnaire was designed to place the candidate devices on a preference scale. This was accomplished through two independent techniques and the results were compared. The preference scale shows whether oral or visual information is preferred and identifies the particular device liked best by the motorist.

Each device presented freeway traffic conditions and conditions at controlled ramps. Because the surveillance project is currently operating a ramp control system, the staff felt that unusual ramp delay might be important to the motorist.

The candidate devices tested were as follows:

1. A symbolic map with arrows showing traffic conditions (Fig. 1a);
2. A symbolic map with arrows and an indication of where the driver was within the highway system (Fig. 1b);
3. A changeable-message matrix sign (Fig. 1c);
4. A roadside radio system;
5. A commercial radio traffic broadcast; and
6. A null alternative, using experience only.

The purpose of the fifth portion of the questionnaire was to determine driver response to traffic information as presented on some of the devices previously listed. Devices 1, 3, 4, and 5 were each used to provide information about six levels of congestion. The respondent was asked to make a route selection decision based on the information from each device for each level of congestion.

Comparisons by levels of congestion and by device were made. By comparing the response to different devices at the same level of congestion, the strength of the devices could be examined. By comparing the response to different levels of congestion as presented on the same device, the ability of the device to promote a consistent response pattern could be probed.

Socioeconomic and travel characteristics were obtained in the sixth section.

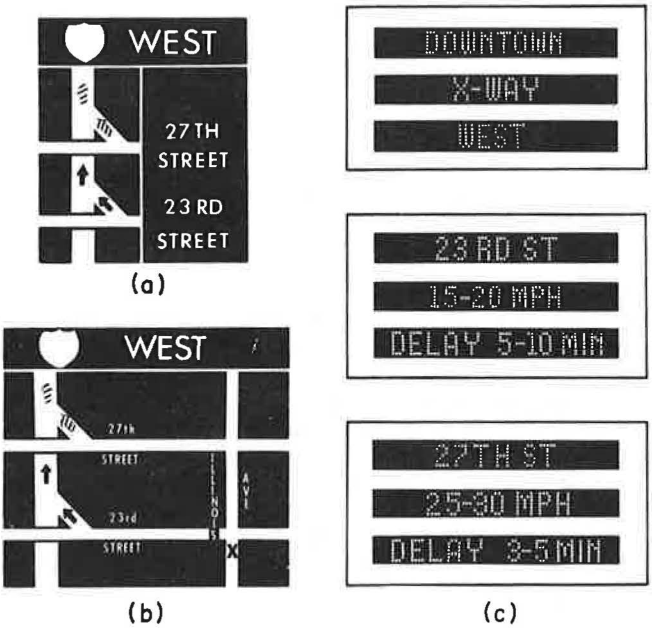

Figure 1. (a) Symbolic map (arrows change color); (b) symbolic map with arterial streets (arrows change color); (c) matrix sign.

Administration of the Questionnaire

Extensive use was made of slides, movies, and tape recordings to demonstrate each device as realistically as possible. Therefore, separate tests for each individual were not practical, and administration of the questionnaire to groups was necessary. Groups consisted of Army Reserve personnel, junior college students, truck driver trainees, and employees of Chicago's Bureau of Public Works. The groups ranged in size from 12 to 60 individuals, and 189 usable questionnaires were obtained.

DRIVER PREFERENCE

In the 1920s, Thurstone developed an experimental technique with which a set of stimuli could be placed on a scale indicating some psychological judgment such as preference, beauty, or loudness (13). The technique consists of presenting to a respondent a pair of stimuli—in this case two different information presentation devices—and asking him to choose the one that best meets some stated criteria.

All possible paired combinations of stimuli are presented for choice. If n stimuli are being considered and there would be no difference in response due to order within the pair, $(n(n-1))/2$ pairs must be tested. By having one respondent make the choice of the same stimulus pairs many times or by having a large number of respondents make the choice once, a frequency of choice of one stimulus over another stimulus can be derived. The frequency of preference of stimulus j over stimulus k for all pairs of stimuli can then be summarized in tabular form.

One can picture the discriminantal process associated with evaluation of a stimulus on a psychological continuum as in Figure 2. The scale value given to the stimulus is S_j, which is the mean of the distribution of the discriminantal process on the continuum. The distribution is not single-valued because at different times or under different conditions variations can be expected to occur in the discriminantal process. Thurstone has assumed that this distribution is normal and can be adequately described by the mean and variance.

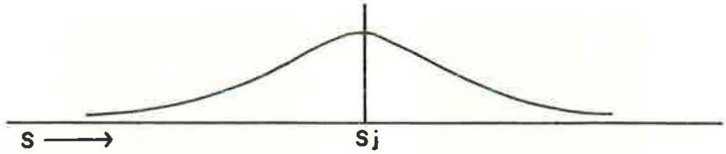

Figure 2. Discriminantal process.

When two stimuli are being compared, the distance between the two means is used to provide the scale distance along the continuum (Fig. 3).

Any single presentation of a stimulus to an observer results in a discriminantal process: d_j or d_k. The difference in the discriminantal processes (d_k - d_j) is termed a discriminantal difference. This discriminantal difference also forms a normal distribution on a continuum. The mean value of the d_k - d_j distribution is used as the difference in scale values for the two stimuli. The distribution of discriminantal differences in shown in Figure 4.

The shaded portion shows the proportion of the distribution where (d_k - d_j) is positive. The value X_{kj} is the mean and is measured in units of the deviation, $\sigma_{d_k - d_j}$ of the distribution. Then

$$S_k - S_j = X_{jk} \cdot \sigma_{d_k - d_j}$$

since

$$\sigma_{d_k - d_j} = (\sigma_j^2 + \sigma_k^2 - 2r\sigma_j\sigma_k)^{1/2}$$

where r = correlation between σ_j and σ_k

$$S_k - S_j = X_{jk} (\sigma_j^2 + \sigma_k^2 - 2r\sigma_j\sigma_k)^{1/2}$$

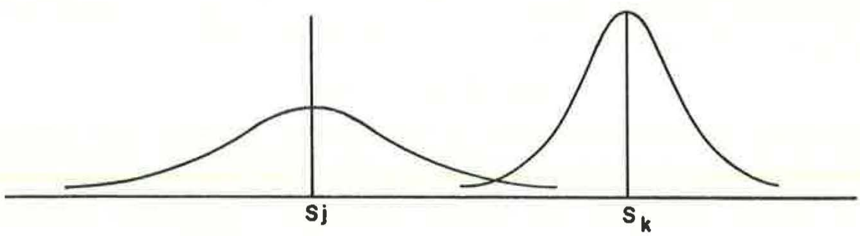

Figure 3. Comparison of two processes.

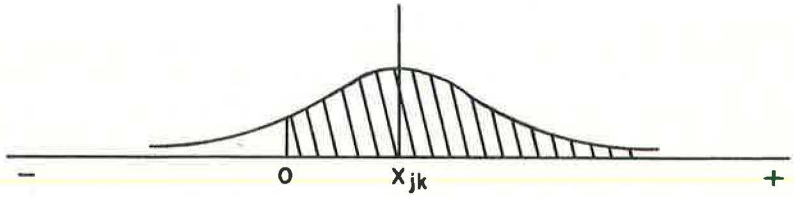

Figure 4. Distribution of discriminantal differences.

which is the formal statement of Thurstone's Law of Comparative Judgment.

The equation in this form is insoluble because there are more unknowns than available equations. Various simplifying assumptions have been worked out by both Thurstone and Torgerson (14, 15). The pertinent simplification to be used here is Thurstone's Case 5, which assumes that the deviations are equal and the correlation is zero for each pair of stimuli. The law then reduces to

$$S_k - S_j = X_{jk}C$$

$$X_{jk} = \text{discriminantal difference}$$

Torgerson notes that the same solution can be obtained by assuming equal deviations and equal correlations. Since C is only a scale factor it is set equal to unity.

Calculation of Preference Scale

A series of respondents are required to make a preference judgment for each of the stimuli pairs. From their responses a matrix indicating the proportion of trials that j is preferred to k is prepared. It should be noted that

$$P_{kj} = I - P_{jk}$$

P_{kj} = Proportion of trials in which k is preferred to j

P_{jk} = Proportion of trials in which j is preferred to k

From this proportion matrix, another matrix, the X matrix, is constructed. Each cell of the X matrix is equal to the standard normal deviate corresponding to the same cell in the proportion matrix. The scale values are then obtained by averaging the columns of the X matrix. Usually the smallest scale value is assumed to be the zero point and the remaining values are adjusted accordingly.

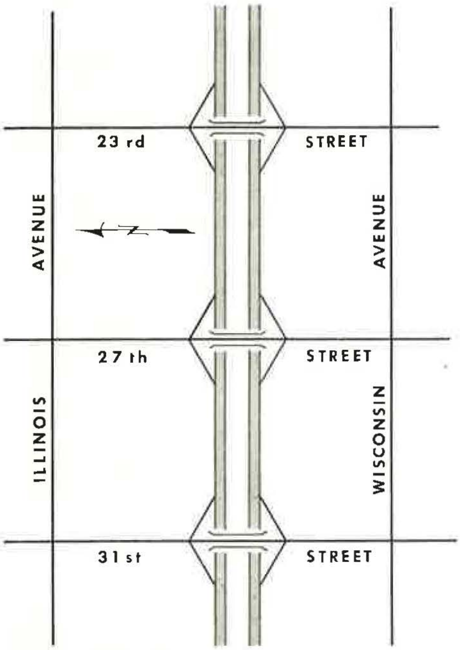

Figure 5. Street system map.

Conduct of Experiment

Five techniques for presenting traffic information to the driver were used as stimuli along with an alternative representing the current method based on driving experience used as a null alternative. The respondents were first introduced to the concept of color coding of traffic information in the questionnaire through the use of a short motion picture. The film showed traffic conditions on an expressway from both an overhead and an in-car view. The first portion of the film showed the traffic conditions corresponding to the congestion level at which the freeway arrows on a symbolic map (Figs. 1a and 1b) would change from green to yellow. The next portion of the film presented the traffic conditions on the expressway which would cause the arrow to go from yellow to red. Finally, the process of ramp metering was shown and the problem of queue development was explained. In this explanation, the inability of current detection systems to estimate ramp delay accurately was mentioned.

The following traffic situation was explained with the use of a map (Fig. 5):

"Suppose that on the expressway westbound traffic is moving at 20 mph at 23rd Street, 25 to 30 mph at 27th Street, and 40 to 45 mph at 31st Street. You want to use the westbound Downtown Expressway and hope to enter at one of the ramps shown on the map. All of these ramps are controlled. There is a 5- to 10-minute delay at the 23rd Street ramp, about a 3-minute delay at the 27th Street ramp, and less than a minute delay at the 31st Street ramp."

The manner in which each of the six alternative techniques would present the information from this situation was demonstrated to the respondents:

Alternative 1, Driving Experience—A slide depicting a suburban arterial intersection was shown.

Alternative 2, Symbolic Map With Arrows—A slide of the device was shown with the freeway and ramp arrows for 23rd Street red and the arrows for 27th Street yellow.

Alternative 3, Symbolic Map With Arrows and Arterial Street—The same information was shown as in alternative 2.

Alternative 4, Changeable Message Matrix Sign—Three successive messages were shown. Each message was shown for 2 sec to simulate viewing time while approaching the sign, as follows: First,

DOWNTOWN
X-WAY
WEST

Second,

23RD ST
15-20 MPH
DELAY 5-10 MIN

Third,

27TH ST
25-30 MPH
DELAY 3-5 MIN

Alternative 5, Roadside Radio—A cartoon of a car with a small radio transmitter adjacent to it was shown to accompany the following tape recording:

"At the 23rd Street entrance ramp to the westbound Downtown Expressway, there is a 5- to 10-minute delay and the expressway is moving at 15 to 20 miles an hour. At the 27th Street entrance ramp there is a 3- to 5-minute delay and expressway speeds are 25 to 30 miles an hour. At 31st Street there is no ramp delay and speeds are 45 miles an hour. To reach 27th or 31st Street, take a right at the next intersection."

Alternative 6, Commercial Radio Traffic Broadcast—A cartoon of a helicopter transmitting information to a car was used to illustrate the following tape recording:

"And now on the westbound Downtown Expressway, traffic is heavy to 29th Street where it opens up. There is a ½-block back-up at the 23rd Street entrance ramp."

The information presented by each alternative technique was made to correspond as closely as possible to the capabilities of the technique and the data that would be available for its use.

The respondents were then presented all possible pair combinations of the six alternatives and asked to indicate on the response form which member of the pair they felt gave the best information. The order in which the pairs and the members within the pairs were presented was randomized to ensure that the same sequence was not used for any test group.

Results of the Experiment

The 189 questionnaires were summarized and the proportion matrix was constructed (Table 1). From these data the X matrix was constructed and the scale was derived as given in Table 2. A scale diagram was made as a graphic presentation of the results (Fig. 6).

TABLE 1
PREFERENCE PROPORTION

Alternative k	Alternative j					
	1	2	3	4	5	6
1	—	0.8836	0.8730	0.8836	0.7619	0.7937
2	0.1164	—	0.5714	0.6243	0.4286	0.4021
3	0.1270	0.4286	—	0.5926	0.3651	0.4392
4	0.1164	0.3757	0.4074	—	0.3122	0.3492
5	0.2381	0.5714	0.6349	0.6878	—	0.5608
6	0.2063	0.5979	0.3608	0.6508	0.4392	—

Note: Each cell represents the proportion of trials that alternative j was preferred to alternative k.

Alternatives:
1. Experience
2. Symbolic map with arrows
3. Symbolic map with arrows and arterial streets
4. Changeable message matrix
5. Roadside radio
6. Commercial radio

TABLE 2
X MATRIX

Alternative k	Alternative j					
	1	2	3	4	5	6
1	—	1.19	1.14	1.19	0.71	0.81
2	-1.19	—	0.18	0.31	-0.18	-0.24
3	-1.14	-0.18	—	0.23	-0.34	-0.15
4	-1.19	-0.31	-0.23	—	-0.49	-0.38
5	-0.71	0.18	0.34	0.49	—	0.15
6	-0.81	0.24	0.15	0.38	-0.15	—
Xka	-5.04	1.12	1.58	2.60	-0.45	0.19
Xka/n	0.84	0.19	0.26	0.43	-0.08	0.03
Scale	0.00	1.03	1.10	1.27	0.76	0.87

In general, visual sources of information appeared to be preferred to oral sources. As could be expected, experience was the least preferred alternative. Using a method suggestea by Heathington, successive pairs of alternatives were tested for significant difference (2). All were significant at the 95 percent level except the two symbolic maps and the two radio techniques. The internal consistency of the data was checked and found to be adequate.

In summary, then, if a driver were able to choose a device for presentation of traffic information, a changeable message matrix sign would be preferred. The choice is not unexpected when the results of Heathington's work, which showed that drivers prefer speed to any other traffic descriptor, are taken into consideration (2). Because the symbolic maps with color-coded arrows provide a qualitative description of traffic conditions, they would be less preferred than the changeable message matrix, which provides speed data.

The general preference for visual displays over oral presentations, although not necessarily surprising, is more difficult to rationalize. Perhaps the driver feels that he may have a difficult time extracting the pertinent information from an oral presentation. If he is not listening very carefully, he may miss the information thar is important to him.

The changeable message matrix sign offers one important advantage over the other visual techniques. With the proper control circuitry, the information displayed can be changed to provide specific information about special traffic situations such as accidents, lane blockages, and reduced capacity.

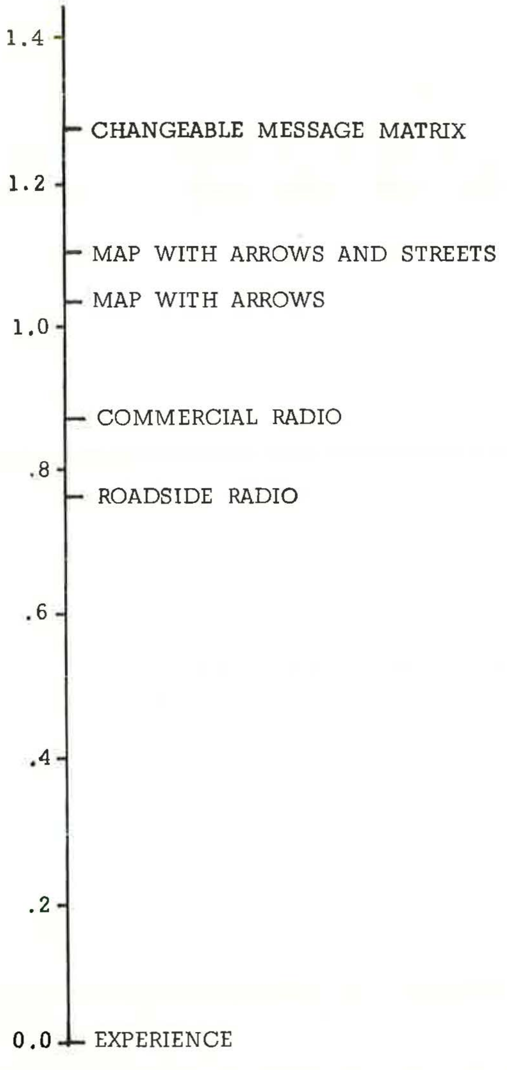

Figure 6. Preference scale.

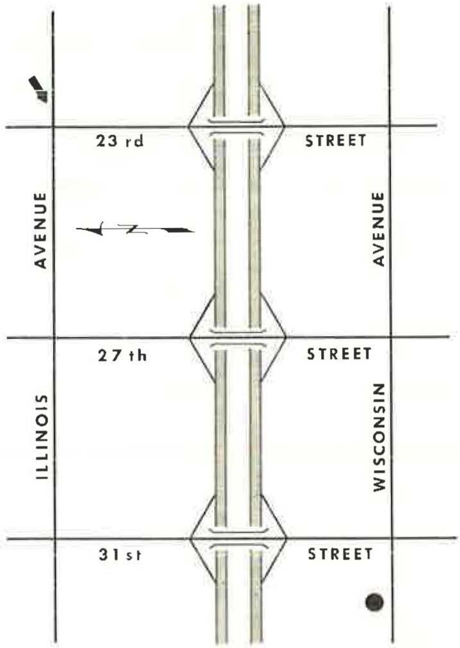

Figure 7. Diversion map.

DRIVER RESPONSE

Ultimately, a traffic information system must be able to influence the actions of drivers in such a way that they are encouraged to increase the level of efficiency in the roadway system. The device most preferred by the driver for presenting information will not necessarily cause the proper actions on the part of the driver to occur. It is therefore necessary to investigate how the driver responds to each of the candidate systems in terms of whether he makes a correct route selection based on the information that is given to him, and which device provokes the strongest response based on a given level of traffic information.

In order to test driver response, each respondent was presented with a traffic situation in which he had to decide whether to use an expressway route or an alternate route. He was given traffic information concerning the expressway route, and this information was varied to provide six levels of traffic service on the expressway. Each of these six levels was presented over four of the candidate systems.

The first candidate system used was the symbolic map with colored arrows. The second candidate system used was the changeable message matrix sign. The third system was the roadside radio, and commercial traffic broadcast was the fourth system considered.

The questionnaire introduced the traffic situation as follows:

"Now I'm going to ask you to pretend that you are driving a car on your way home. It is the evening rush hour, and you are planning to use the expressway. You are approaching an intersection where you must decide whether to use the nearest ramp to get on the expressway, or to use the city streets to go to the next nearest ramp, or to use the city streets for your entire journey. The situation is shown on this map (Fig. 7). Your car is in the same position as the arrow. Your home is about 10 miles away, shown by the circle. The city street is an average suburban business street. The traffic conditions are shown in this film. (The film depicted a 3-minute trip down the suburban arterial street in the Chicago metropolitan area.) Now I am going to give you some traffic information and ask you if you will (a) use the nearest ramp, or (b) not use the nearest ramp."

The information was presented in the same format that was used in the preference scaling part of the questionnaire; however, in this case the level of congestion in the area of 23rd Street was varied. The level of congestion on other portions of the expressway remained the same. Six levels of congestion were chosen at 23rd Street to be representative of most of the conditions that would be considered by a motorist. The manner in which the information was presented is given in Table 3.

For each group the order in which the information was presented was randomized to minimize the effects that might have occurred because of the people remembering how they responded to a particular piece of information as presented by another device or how they responded to other information presented by the same device. The information was summarized as the proportion of the sample that indicated they would divert from the nearest entrance ramp based on the information as it was presented to them. This information is shown in Figure 8.

Comparison of Devices

The diversion patterns shown in Figure 8 were used to compare the devices against each other to determine whether one device would cause a significantly higher or lower

TABLE 3

CONGESTION LEVEL INFORMATION

Amount of Delay Caused by Using 23rd St. Ramp	Symbolic Map[a]	Changeable Message Matrix[b]	Roadside Radio[c]	Commercial Traffic[d]
-2 min	Freeway-Green Ramp-Green	23rd St 45-55 mph Delay 0-3 min	A. 0 to 3 B. 45 to 55	A. Light B. No
+1 min	Freeway-Green Ramp-Yellow	23rd St 45-55 mph Delay 3-5 min	A. 3 to 5 B. 45 to 55	A. Light B. No
+3 min	Freeway-Yellow Ramp-Yellow	23rd St 25-30 mph Delay 3-5 min	A. 3 to 5 B. 25 to 30	A. Moderate B. A short
+5 min	Freeway-Red Ramp-Yellow	23rd St 15-20 mph Delay 3-5 min	A. 3 to 5 B. 15 to 20	A. Heavy B. A short
+6 min	Freeway-Yellow Ramp-Red	23rd St 25-30 mph Delay 5-10 min	A. 5 to 10 B. 25 to 30	A. Moderate B. A 1/2 block
+8 min	Freeway-Red Ramp-Red	23rd St 15-20 mph Delay 5-10 min	A. 5 to 10 B. 15 to 20	A. Heavy B. A 1/2 block

[a] Indications for 27th St. remained yellow.

[b] 23rd St. information preceded by

Downtown
X-way
West

and followed by

27th St
25-30 mph
Delay 3-5 min

[c] Roadside radio (tape recording): "At the 23rd Street entrance ramp to the westbound Downtown Expressway, there is a (A) minute delay and the expressway traffic is moving at (B) miles an hour. The 27th Street entrance ramp has a 3 to 5 minute delay, and the expressway speeds are 45 to 55 miles an hour and there is no ramp delay."

[d] Commercial radio (tape recording): "And now, on the westbound Downtown Expressway, traffic is (A) to 25th Street. From there it is moderate to 29th where traffic opens up. There is (B) backup at the 23rd Street entrance and a short backup at the 27th Street entrance ramp."

level of diversion than the others. The chi-square statistic was used to test between pairs of devices at all levels of congestion. Device 1, which shows a sharp dip in the diversion pattern at the 3-min level of delay, proved to be significantly different from all of the other three devices. In fact the only non-significant difference that was noted was between the changeable message matrix sign and the commercial radio. It should be noted that the overall highest level of response was given by the roadside radio. The next highest level of response was given by the changeable message matrix. The abnormal dip in the diversion pattern for the symbolic map may be indicative of the difficulty that a motorist may have in transforming color-coded information into qualitative information for use in his route selection analysis. Although there were significant differences between each of the devices in terms of the diversion pattern, the absolute amount of change in most cases did not exceed 15 percent, indicating that there is little practical difference between the devices. One must then determine whether the device selected to present the information meets an adequate level of reaction and can satisfy other criteria, among them being cost-effectiveness, ease of installation, and maintenance.

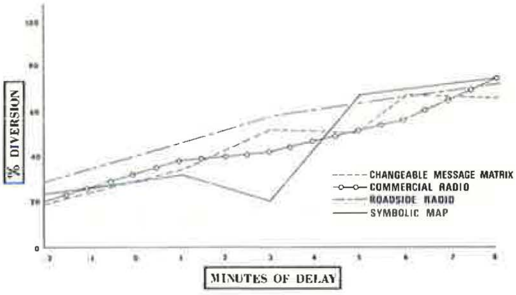

Figure 8. Diversion patterns.

A test of this type gives no real indication of what the motorist would do in terms of actual response to a device in a real driving situation. What has been attempted here is to test reactions under a consistent driving situation to determine whether one device among those tested is either an exceptionally good one, or a very bad one.

From the results obtained it is obvious that the devices performed rather similarly, in that the amount of diversion did tend to increase as the delay caused by using the nearest entrance ramp increased. In most cases it was apparent that the delay or the amount of diversion could possibly be approximated by a linear function of minutes of delay, with the exception of the delay pattern caused by the symbolic map. The symbolic map for that reason may prove to be a somewhat less desirable device than the other three. However, among the other three, it is very difficult to choose one solely on the basis of these data.

Correctness of Response

With data collected under a laboratory situation such as this it is difficult to make rigorous statements concerning the correctness of the response of the individuals to the information. In general, as the amount of delay approached the zero minute level, the diversion rate began to approach 30 to 35 percent. This would indicate that approximately one-third of the population interviewed feels that with no time advantage coming from using the expressway the comfort and convenience offered by the alternate route would be preferable. At the high level of congestion, 8 min of delay, diversion approached 70 percent. Since the shortest alternate route trip was only 16 min, this was a 50 percent increase over the shortest alternate route trip. The diversion for this amount of delay seems reasonable. The problem of the response of the motorists to a symbolic map in the 3-min level of congestion casts some doubt on the ability of this particular device to transmit the proper information.

To summarize, in testing the four devices and the six levels of congestion, it was very difficult to pick out any of the four devices as being superior on the basis of overall response. Except for the symbolic map, all the devices gave a reasonable set of responses to the various level of congestion, and none of the remaining three could be singled out as causing obvious errors in judgment on the part of the respondent.

CONCLUSIONS

This report has attempted to look at the traffic information techniques that might be used to divert drivers around congested parts of the highway system. Because the diversion could both increase the satisfaction of the individual and improve the efficiency of the roadway system, it is important that the most effective technique be utilized. From the survey, it was determined that:

1. Visual techniques were preferred to vocal techniques. The changeable message matrix sign was the most preferred technique.
2. The difference in response level between the various techniques was small, indicating that perhaps any one of them, except the symbolic map, would produce the same results.

When both results are considered, the desirability of more intensive consideration of the changeable message matrix sign becomes apparent. A pilot installation of sufficient magnitude to cover a wide range of traffic conditions and to provide a sufficient data base for evaluation should be implemented to determine the effect of such a system of signs.

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