Driver Information Requirements and Acceptance Criteria

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The purpose of this study was to analyze the route guidance information required and preferred by drivers. Required driver information was derived by determining how an unfamiliar driver negotiated a generic intersection. The generic intersection was defined in terms of (a) choice points, (b) characteristics of the approach to the choice point, and (c) characteristics of exit paths.

A driver's task analysis was performed to obtain estimates of time and information required to negotiate complex intersections. This enabled a determination of driver information requirements directly, from the step-by-step task analysis, and indirectly, from the estimates of information lead distance requirements. Driver information was established for approach paths, choice points, target paths, and close sequential choice points. Literature on human capabilities and limitations was reviewed to develop display concepts appropriate for a wide spectrum of the driver population.

Driver acceptance of the ERGS concept, information requirments, display characteristics, and desirability of a partially implemented system was also analyzed. Representative complex route guidance problems together with variations in the driver information requirements and display concepts were presented to drivers. The drivers indicated how they would perform with the displayed information, and which of the displayed information concepts they preferred. Finally, information on driver's preference for implementing the system on primary roads, in central business districts, at critical intersections, or in suburban areas was determined.

•THE Electronic Route Guidance System (ERGS) is based on a concept (1, 2) for furnishing a driver with individual information inside his vehicle that would enable him to accomplish a trip to his specific destination efficiently and safely. The role of this study in the ERGS development program is to identify the driver information requirements, determine the optimal display characteristics for the required information, and evaluate user acceptance of this particular method of furnishing route guidance information.

DRIVER INFORMATION REQUIREMENTS

The basic approach employed (3) in this analysis was to define the relevant factors that influence information requirements within an electronic route guidance system context. Initially, a distinction was made between trip negotiation, as conceived of in an ERG System, versus that under current route guidance methods. Current route guidance systems (highway route numbers, mileage signs, street names, maps, etc.) furnish information aimed at all drivers; the information is necessarily incomplete and presented intermittently, and the system relies on the driver to integrate it with his

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desired destination and make his own decisions at each choice point. ERGS, on the other hand, is conceived of as a way of computing and presenting the proper choice to each driver at every instrumented choice point or intersection, based on his specific destination. Thus, within an ERGS context, trip negotiation is defined as the process of efficiently getting a driver through a choice point or a series of choice points.

To understand this distinction, it was necessary to identify and define all of the relevant components of intersections as related to choice point decisions. Once having described an intersection as a choice point or series of choice points, it was then necessary to define as precisely as possible the driver's task related to the negotiation of those points. Consideration was given to those tasks directly influencing information requirements and those relating to lead distance components, such as lane-changing and speed-changing maneuvers. It was necessary also to identify the relevant response time factors as related to the capabilities and limitations of drivers in performing the driver task. These time factors are obviously important in the derivation of information lead distance requirements. Furthermore, the driver's tasks were oriented around the behavior that would characterize an unfamiliar driver, that is, a driver who knew neither the route nor the other characteristics of the roadway. The assumption is that the information and lead time necessary for an unfamiliar driver to negotiate an intersection efficiently will also be appropriate for all other types of drivers. This assumption was further modified by considering the unfamiliar driver with limited capabilities (that is, poor visual characteristics, and/or other limiting sensory-psychological factors), thus establishing a basis for the identification of maximum information requirements and lead distance components (3, Appendix C).

In the process of analyzing the driver's task, two task elements emerged as most relevant for the determination of information lead distance. These elements are changing lanes to prepare for a maneuver and changing speed to perform the maneuver. At an intersection, the lead distance for the initial information can, thus, be determined as a function of the requirement to change lanes and the requirement for the slowest possible exit speed from the choice point. These factors are influenced by other limitations imposed on the unfamiliar driver in light of speed, vehicle characteristics, environmental considerations, and other generic network characterisitcs. Therefore, the determination of information lead distance for a specific choice point took all of the above factors into account.

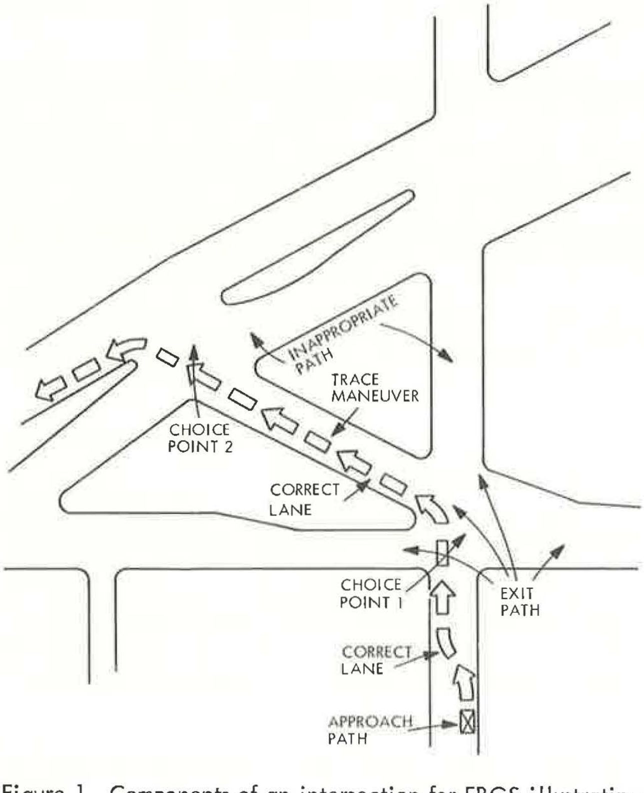

Figure 1. Components of an intersection for ERGS illustrating two close sequential maneuvers.

The next step in establishing the information requirements was to re-examine the driver's task and information requirements for a specific network in light of lead distance factors. The reason for this is that the lead distance required by a given choice point has within it the potential for generating additional driver information requirements. Specifically, as lead distance for one choice point increases, there is also an increase in the number of intervening choice points that could be considered potential exit paths for the driver.

Finally, the information requirements that had been identified through analysis were verified in the user acceptance study.

Definition of Intersection Components

For purposes of the ERGS study, intersection components or characteristics are defined primarily in light of the way in which a driver traverses the roadway where there is a choice point, or "nodal gore." This is in contradistinction to conventional intersection classification schemes, which are generally based on features obvious from a plan view rather than on the factors that affect driver behavior and information requirements. The classification scheme (Fig. 1) is oriented around the path components that are legitimate considerations to the driver approaching a choice point, as follows:

1. Approach path—the lane or lanes available to traffic entering the intersection or choice point.
2. Choice point, or nodal gore—the point at which a driver can choose between two or more exit paths, any one of which is available for travel by him. This does not include the choice between two lanes of the same approach, although drivers often must choose between two or more lanes to execute correct maneuvers.
3. Exit path—any path of one or more lanes leading away from the choice point.
4. Target path—the correct path beyond a choice point, for a specific driver-destination combination. Target path is distinct from exit path in that it may define a specific lane on the exit path.
5. Inappropriate path—a competing exit path near, at, or beyond a choice point that may appear to a driver to be the one he is seeking.
6. Trace—the path a vehicle would follow from an approach lane to an exit lane.
7. Sequential choice points—any series of choice points that occurs in sequence and that requires a corresponding series of maneuvers (close sequential maneuvers) by a driver to follow a specific trace.
8. Correct lane(s)—lane(s) permitting efficient and legal negotiation of the choice point. Correct lanes may be identified for the approach path, the choice point(s), or the target path.

Driver's Tasks at an Intersection

To determine the information drivers require in the way of route guidance at an intersection, one must first determine what a driver does at an intersection. The general tasks were limited to those perceptions, detections, and executions that are specifically required to negotiate intersections (Table 1).

TABLE 1

DRIVER TASKS IN INTERSECTION NEGOTIATION

1.	Perceive presence of route guidance source.
2.	Perceive potential path change requirement.
3.	Perceive approach path maneuver requirement, i.e., lane change.
4.	Execute lane-changing maneuver.
5.	Perceive specific guidance direction.
6.	Perceive approach path maneuver.
7.	Perceive need to change speed.
8.	Execute speed change.
9.	Detect node (put intersection into perspective).
10.	Detect end of route.
11.	Detect inappropriate path(s) on approach.
12.	Detect conflicting oncoming traffic.
13.	Detect obstruction in or near roadway.
14.	Determine need to stop.
15.	Stop auto.
16.	Detect target path.
17.	Detect inappropriate paths at choice point.
18.	Perceive choice point maneuver.
19.	Execute maneuver at choice point.
20.	Detect close path sequence.
21.	Execute close path sequence.
22.	Perceive target path verification.

The driver's task in the ERG System was developed around the concept of an unfamiliar driver (i.e., the driver who is making his first appearance at a given intersection). If the system can adequately guide this unfamiliar driver through the system, then all other drivers can use those portions of the displayed information that satisfy their particular needs.

The two primary components that were sought in developing the driver's task while negotiating a generalized intersection were those that had an impact on driver information requirements and those that affect information lead distance.

The information requirements are affected by the following conditions:

1. It is a partially implemented system; therefore, the existence of instrumentation at the given intersection must be brought to the driver's attention.
2. There may be a requirement to change lanes in order to effect the intersection on a multiple-lane, one-direction roadway.
3. The lead distance required to effect major intersections might be such as to have competing roadways prior to the intersection.
4. The guidance information presented is on an advisory as opposed to a command basis; therefore, the driver must attend to current traffic regulations.
5. There are certain close choice points in a trace that may require multiple guidance messages to be presented prior to actual trace negotiation.
6. The next intersection or choice point could, in fact, be the destination desired by the driver.

The driver tasks do not take into account the initial input of destination information, route, or the selection of route type that might be preferred by the driver. Not all tasks are applicable to all choice points, and some tasks may have to be repeated on certain traces; for example, lane changing where there are more than two lanes in one direction.

Information Lead Distance

The lead distance calculations are based on estimates of the times required by drivers with a wide range of capabilities to perform the tasks involved in negotiating an intersection.

In establishing information lead distance from a choice point, it also is possible to identify requirements for close sequential maneuvers. This is done essentially by establishing the maximum lead distance for the required worst case maneuver, and determining whether this distance would extend beyond the prior choice point(s). If it does, then successive maneuvers are required, since the ERGS information must be provided before the previous choice point. Thus, in the application of the information lead distance requirement from any choice point, we may (in fact) establish additional information requirements, such as close sequential maneuvers, lane requirements beyond a choice point, and identification of conflicting inappropriate paths at or beyond a choice point.

The worst case condition for lane changing is the one in which the driver is in the worst possible lane under heavy traffic volume condition, and going at the maximum speed for the roadway under consideration. The worst case condition must also take

TABLE 2

INFORMATION LEAD TIME AND DISTANCE REQUIRED FOR WORST CASE-WORST DRIVER LANE-CHANGE MANEUVER

Function	Time (sec)	Average Speed (mph)	Distance (ft)
Lane change			
Detect ERGS present	2.5	40	147
Detect right lane required	2.5	40	147
Detect need to change lane	1.9	40	112
Detect aft car	5.5	40	323
Detect cars in right lane	5.5	40	323
Wait for acceptable gap			
Initial deceleration	1.63	35	84
Waiting speed	25.5	30	1,125
Change lanes	4.5	30	198
Total			2,459

TABLE 3

INFORMATION LEAD TIME AND DISTANCE REQUIRED FOR WORST CASE-WORST DRIVER SPEED-CHANGE MANEUVER

Function	Time (sec)	Average Speed (mph)	Distance (ft)
Speed change			
Turn right guidance	1.9	30	84
Red light ahead	3.8	30	168
Rule out prior path(s)	1.9	30	84
Slow down and stop	4.9	15	147
Total			483

into account the requirement to change speeds at any given choice point. The worst case condition is deceleration from the maximum speed on the approach to the safe speed for the most difficult turning maneuver at the choice point. Once these have been established, the time factors for the limited capability driver effecting these tasks must be developed.

Table 2 presents a list of tasks for the lane-changing maneuver. The lane-changing maneuver has many components relative to acquiring the forward, aft, and side positions of potentially competing vehicles. These occur after the driver has perceived the need to change lanes. He must not only determine the position of competing vehicles, but also their velocities relative to his own and to the path of interest. In addition, a driver must wait for an acceptable gap (3 Appendix D) to occur before maneuvering into the desired lane. On a multilane road, these tasks must occur for each lane change.

The speed-changing maneuver (Table 3) requires that the driver put competing vehicles along the approach into perspective. Obviously there is a need to insure that a following vehicle is not so closely behind that a decrease in speed will create a hazardous situation. Furthermore, the position and velocity of vehicles on the immediate side and front must be taken into account. Finally, the maneuvering times relative to whether the speed change is one of deceleration (the more normally anticipated maneuver at a choice point) or acceleration must be taken into account.

Driver limitations and capabilities were examined (3, Appendix C) in terms of the driver's ability to perceive, detect, and respond to events in the roadway that are critical to the driving task. Specifically, these ranges of capabilities, as they relate to task times, were applied to driver tasks for lane and speed changes.

Generic network characteristics affect information lead distance to the extent that they influence vehicle speed and the driver's visual task load. The most relevant characteristics are the number of lanes in the approach path, special turning lanes or lane prohibitions, and, of course, the number of possible exit paths at a choice point.

Applying these factors, the maximum possible lead distance for performing the lane change to the left and stopping maneuver for choice point number 1 on the generic intersection was calculated. It assumed a truck merging left; traffic density of 1,000 vehicles per hour; approach speed of 40 mph; an aged driver with long perception, decision, and maneuvering times; and poor visibility conditions on a wet surface. The serial analysis of worst case-worst task time makes it immediately clear that an excessive amount of lead time is required. If one differentiates between the information lead time required for lane changing, and that for speed changing, it can be seen that lane-change information is required at 2,459 feet, while speed-changing information is required at 483 feet, for a total of 2,942 feet.

This is based on a series of operations always using the worst case data. This is probably unrealistic and an answer to this particular problem requires further study. However, the above calculations suggest that it would be desirable to present lane-changing information to all drivers at all choice points, at the maximum information lead distance, unless this information could be presented at the prior intersection.

The information requirements at three points in the trace maneuver of Figure 1 on the approach path, at the choice point, and while negotiating close sequential choice points are depicted in Figure 2.

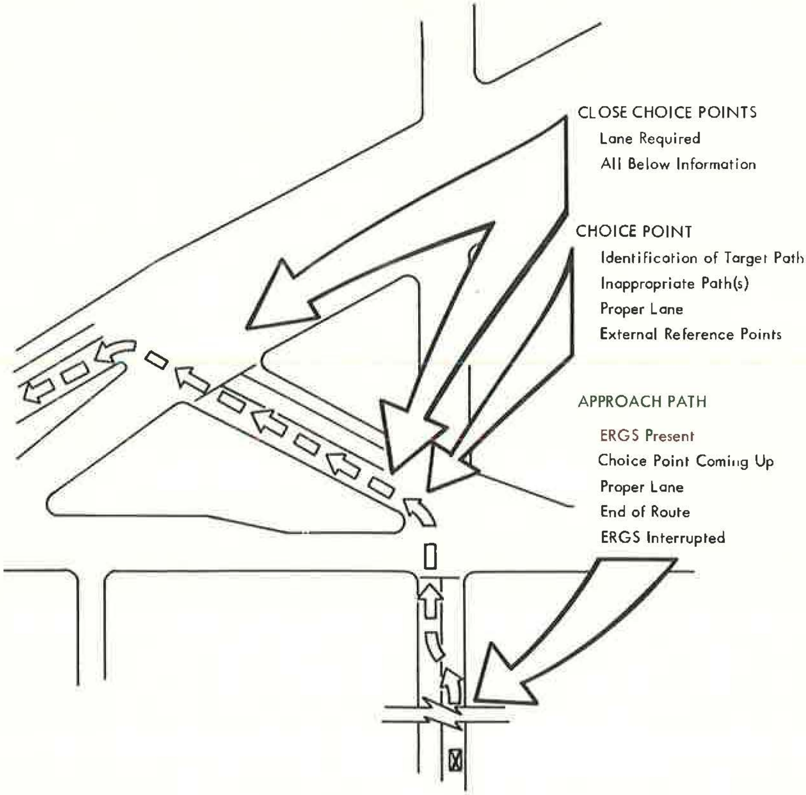

Figure 2. ERGS driver information requirements illustrated for a close sequential maneuver.

USER ACCEPTANCE STUDY

A user acceptance study was conducted to determine the general acceptance of this type of guidance system, identify the types of roads where it would be most useful, and verify some of the information requirements and display concepts that had been generated. The approach was to explain ERGS by means of a film, and to use the film to ask questions and an associated questionnaire to record answers.

Data were collected with the film/questionnaire "Guiding Tomorrow's Motorist" from audiences at the History and Technology Museum of the Smithsonian Institution. More than 1500 persons completed the survey questionnaire. Stringent exclusion of inconsistent and incomplete responses resulted in a sample of 561 that was used for the analysis (Table 4).

System Considerations

Ninety-four percent answered in the affirmative and four percent were undecided when indicating whether the Electronic Route Guidance System is desirable. ERGS symbols and words were preferred to conventional signing, 84 percent answered yes, 15 percent didn't know and only one percent indicated that ERGS was not better than conventional signing. Despite the apparent favor with which ERGS information was viewed, respondents were more reserved when asked whether they would buy ERGS equipment. Only 43 percent indicated that they would, 39 percent were undecided, and the remainder (18 percent) indicated that they would not. An indication of the relationship between need for the system (frequency of getting lost) and acquisition is shown in Figure 3. It is obvious that those people who get lost frequently would buy the system.

TABLE 4

RESULTS OF ERGS PUBLIC ACCEPTANCE STUDY
(Sample = 561 Licensed Drivers)

System Considerations	Yes	Don't Know	No
ERGS good idea	94%	4%	2%
Public buy	43%	39%	18%
Better than signs	84%	15%	1%
Cost Consideration	Would Buy		
	Yes	Don't Know	No
	$149	$221	$248
System Implementation	Most		Least
Highway connecting suburbs and downtown	37%		3%
Interstate connecting cities	23%		32%
Downtown shopping and business	24%		20%
Suburban shopping and business	7%		5%
Suburban residential	4%		22%
City residential	4%		18%
Information Requirements	Yes	Don't Know	No
Lane change	87%	6%	6%
Inappropriate paths	75%		25%
External signs	92%		8%

Display Consideration	Preference
Placement:	
Head-up (on windshield)	78%
Dash-mounted	22%
Lane-change information:	
Sound alone	1%
Sight alone	37%
Sound and sight	28%
Warning tone and sight	34%
Arrows vs words for lane changing:	
Words alone	3%
Arrows alone	15%
Both	81%
Optional routing solution:	
Safer routes	26%
Least time	63%
Least cost	2%
Most scenic	9%

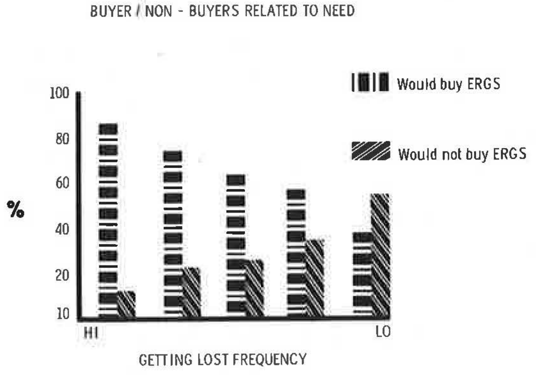

Figure 3. Relationship between frequency of getting lost and system acquisition.

Cost Considerations

Respondents were asked to indicate their estimate of the cost of in-car equipment enabling them to use the ERG System. As shown in Table 4, the average cost estimate for buyers was $149, for non-buyers it was $248, and for those who were undecided, $221. Taking the sample as a whole and without reference to whether or not ERGS equipment would be bought, the cost estimate was $195.

System Implementation Considerations

Given the following choices—downtown shopping and business areas, city residential areas, suburban residential areas, suburban shopping and business areas, Interstate highways and highways connecting suburban areas and downtown areas—respondents most frequently indicated that ERGS routing information would be most useful on highways connecting suburban areas and downtown areas (37 percent). On the other hand, urban and suburban residential areas were not favored as locations for installation of the system. Downtown shopping streets and highways connecting cities were regarded by some as desirable locations, with nearly as many in each case.

Lane-Change Information

The majority of respondents felt that lane-change information was necessary (87 percent). Only six percent felt that lane-change information was not necessary, and six percent were undecided.

Identification of Inappropriate Paths

Respondents were asked to indicate their preference to two symbols that provided turning information at an intersection. One symbol showed the correct path in green and the incorrect paths in red. The other showed only the correct path in green. Seventy-five percent of the respondents preferred the symbol showing both correct and incorrect paths for turning information.

External Signing

Respondents were asked whether they preferred to have exit information from an expressway presented solely in the car (for example by being told to "take the third left") or whether they preferred a combination of in-car information keyed to external signing (for example, by being told to take "ERGS 4" where ERGS 4 was indicated by an external sign). The overwhelming majority of respondents preferred the combination of in-car information and external signing (92 percent).

Head-Up Versus Dash Display

The majority of the respondents preferred display of ERGS routing information by means of a head-up display rather than by a dashboard display. Respective percentages for these two answers were 78 and 22 percent. Those who indicated they would buy ERGS preferred a head-up display even more than non-buyers, with 84 percent indicating this preference. Aged drivers also showed a marked preference for the head-up display.

Method of Presentation of Lane-Change Information

When asked to indicate their choice between four possibilities for presentation of lane-change information—namely by sound alone, sight alone, sound and sight, or a warning tone and sight—almost no one preferred sound alone (only 1 percent of the sample). Thirty-seven percent preferred sight alone, 34 percent preferred a warning tone and sight, and 28 percent indicated that they preferred sound and sight. Interestingly, while sight alone was most frequently preferred by the total sample, the most frequent choice by buyers was a combination of sound and sight (40 percent of buyers). Another large percentage of buyers indicated that they preferred a warning tone and sight (36 percent). Also with increasing age drivers tended to select both sound and sight. It therefore appears that the majority of buyers would prefer some combination of sound and sight for lane-change information.

Presentation of Lane-Change Information

Respondents were asked whether they preferred messages composed of arrows alone, words alone, or a combination of arrows and words. The majority (81 percent) indicated a preference for the latter choice, while 15 percent preferred arrows alone and only 4 percent preferred words alone.

Basis for Optimal Routing Solution

Initially, the ERG System will probably not allow those with implemented vehicles to vary their basis for route selection (i.e., safety, scenery, etc.). To establish a routing criterion, respondents were asked to state the basis upon which they generally selected routes. The options were safety, least time, least cost, and scenic value. The majority (63 percent) opted for routes that take less time. Second choice was safety (26 percent), followed by scenicness (9 percent) and cost (2 percent).

DISPLAY CONCEPTS

The final step was to develop display concepts from:

1. The analytically derived and acceptance study verified driver information requirements for negotiating intersections.
2. An analysis of other ERG System display concepts that have been developed to this stage.
3. Public acceptance of various display concepts determined from the film questionnaire.

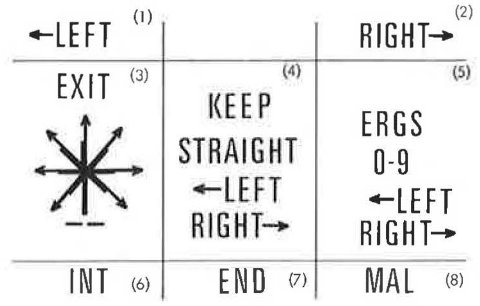

Figure 4. Route guidance information display concept (circled numbers are not in the display concept but related to text).

4. A design driver resulting from an analysis of driver capabilities and limitations. The design driver is an aged individual with inherent perceptual limitations related particularly to visual acuity and accommodation. The design driver's characteristics were used to establish presentation principles. The rationale for taking the aged driver was the fact that there are more than 13,200,000 people over 60 years of age who currently drive (Automobile Manufacturers' Association, 1968), and a display designed around the limitations of such a driver should be clearly within the capabilities of more able drivers.

5. Establishing a priority for display concepts that could readily accommodate multiple intersections under conditions requiring close sequential maneuvers and limited antenna placement due to cost constraints.

The concept finally developed would be feasible in both a head-up version (projected on the windshield) and a panel version (on the dashboard), with minor differences between them. However, perceptual characteristics of the aged driver, specifically his inability to shift from roadway tasks to panel display and back to the roadway, strongly supports the head-up display (5).

Key advantages of the head-up display are (a) presentation of information directly in the field of view of the motor vehicle operator, and (b) information is focused at infinity, which reduces requirements for adjustment in convergence. Thus, the head-up display presents information with minimal distraction from external visual tasks.

Figure 4 shows the display concept. At any given intersection only elements required to depict the route guidance message would be illuminated (Fig. 5). Along the approach path the information requirements are (a) the fact that a choice point is coming up, (b) the proper lane for the choice point, and (c) information on whether ERGS is interrupted, malfunctioning, or at the end of the route. The display concept could handle "choice point coming up" in the head-up version by merely presenting the required information, but for the panel display an auxiliary auditory tone or cue for the proper lane is required because the information may not be in the direct field of view of the driver whose attention may be focused on the operations in the roadway. Designation of the proper lane on the approach path is handled on the top line of the display by the words "right" (1) or "left" (2) with appropriate arrows. Arrows and words add redundancy, minimize uncertainty, and were preferred in the acceptance study. Since an ERGS interrupted "INT" (6) message or an end of route "END" (7) would normally be responded to last in any guidance message, this information is presented on the last line of the display. END is shown in red as an indication for stopping and INT in yellow indicating caution and need to revert to other means. MAL indicates system malfunction and is red (8).

At the choice point, the driver is given information enabling identification of the target path as well as inappropriate path information (3). The target path is identified by means of a green arrow on any one of seven equi-angular radials (excluding 180°). These radials provide sufficient flexibility so that the driver can perceive the target path in a manner close to the way that he would perceive the path through the windshield. The appropriate or target path and inappropriate paths are both shape and color coded. The appropriate path is presented by means of the leg to the choice point, and a leg with the appropriate arrowhead beyond the choice point is presented in green. The inappropriate paths are presented as red radials half the length of the path presented for the choice point with no arrowhead characteristics. In addition to inappropriate paths at the choice point, inappropriate path information for one intersection prior to the choice point may be presented. Because it is an inappropriate path it is depicted by means of a red dashed line. An "EXIT" indication (6) for portraying the route guidance command to "EXIT" on Interstate or grade-separated roadways is also presented. The exit word is presented in green above the symbolic configuration for the choice point.

In addition to information on choice point, target path, and inappropriate path, an important feature is the need to show the proper lane at and through the choice point of interest. This information is provided by means of the center portion of the display (4), where the driver can be instructed to keep straight, keep to the right or keep to the left. (Obviously the driver would only receive one of these three commands.) Because lane-change information is required both on the approach path and beyond the choice point, a convention was adopted to code lane-change information in a single color: aviation yellow. By providing lane-change information for the path after the choice point, the probability that the driver will have time to respond to a completely new instruction for the next maneuver is substantially increased. The reason is that normally the maneuvering required to get in the proper lane on the road to effect a subsequent maneuver takes planning, gap acceptance, and other factors requiring substantial lead time.

The display also provides the possibility of fairly complicated sequential maneuvers beyond the initial choice point by means of the information displayed in the right-hand side of the display (5). The display has been designed around the requirement to provide external signing, which is necessary for multiradial traffic circles and some complex interchanges and intersections. It is also consistent with the public's desire to have numbered exits when leaving the Interstate system. Since a 0 to 9 numeric can be presented with the words "right" or "left," it is possible to tell the driver to take

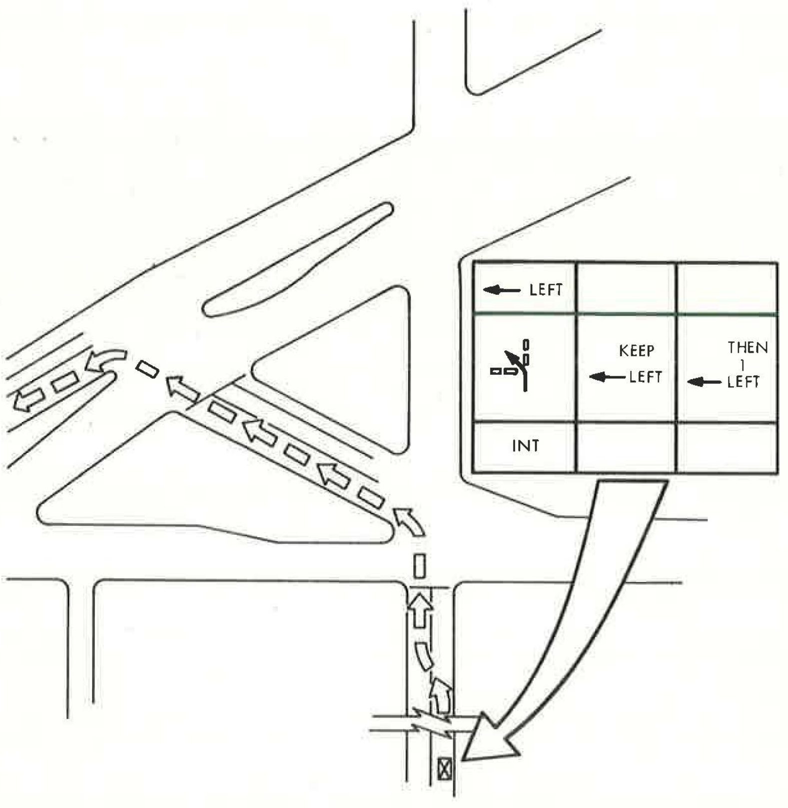

Figure 5. Application of route guidance information display in an intersection illustrating close sequential maneuvers.

up to the ninth right or left. However, it is not recommended that such an approach be applied. Actually to require drivers to take into account more than two streets is probably beyond their capabilities. Both the decline in short-term memory capability of aged drivers and the design goal of keeping complexity and uncertainty to a minimum require a better method of handling such situations. Therefore, if more than two streets have to be accounted for during close sequential maneuvers, which do not permit a new display, then external reference signing using the ERGS 0 to 9 configuration should be applied.

Accordingly, it is recommended that external signs be considered for situations such as traffic circles where more than two streets must be passed before the maneuver can be effected. If the exit from a traffic circle would occur prior to passing two streets, then first or second right or left, depending on the circumstances, would be more appropriate than the reference signing. The reason is that the driver entering into the circle may not have time to perceive the ERGS external reference signs but can readily count up to two streets. The external reference signs should say "ERGS" and not "EXIT," to maintain a distinction between them and the many exit signs already in use on highways. It is recommended that the information for the close sequential maneuver be given in green because it is related to choice point behavior and should be coded in the same manner as the exit symbol for the first choice point.

The last informational bit required is whether there is a malfunction in the system. To handle malfunctions, there is a system status indication that would normally indicate when any part of the system is malfunctioning.

The display presents information that is position, shape and color coded with sufficient redundancy for perceptual ease by the aged driver taken as the design reference point. It provides all of the information necessary to efficiently negotiate complicated close sequential maneuvers in a manner requiring minimal interpretation and memory, and enables the driver to know where to navigate his vehicle at all times in the route negotiation task. It also provides primary status information for the system as well as interrupt conditions and attainment of destination. An application of the display is shown in Figure 5.

SUMMARY

In summary, the driver information requirements derived from an analysis of an unfamiliar driver's task in negotiating an intersection were verified by the public acceptance study. The public thought the system was useful and a substantial portion thought they would acquire the in-car system which they thought would cost under $200.

A route guidance display concept designed around the limitations of an aged driver and the driver information requirements was developed. The concept is based on presenting a clear and unambiguous display of the essential maneuvers required to negotiate close sequential choice points (intersections). The analysis would suggest the use of a head-up display.

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