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Development and Testing of a Traffic Information System Driver Interface

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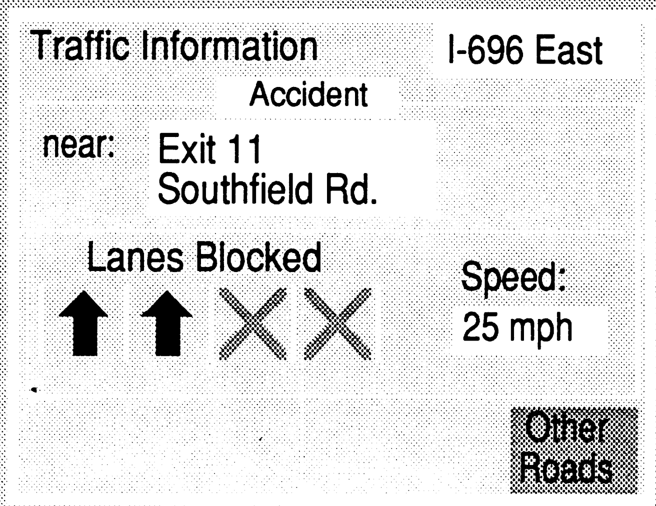

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16. Abstract

This report describes a series of efforts that were carried out to develop safe and easy to use in-car traffic information systems and guidelines, and methods for their evaluation.

Desired information elements were identified based on the literature. Several candidate designs were constructed, some of which were not developed further because of screen space constraints. Using the Keystroke and Tullis Models, designs were eliminated from further consideration or modified, and subjected to quick usability tests concerning information arrangement and retrieval.

Next, at a driver licensing office, 20 patrons were shown color copies of five alternative coding schemes. For presenting traffic information graphically, a green-yellow-red color key was best understood, and it was preferred to include actual travel speeds.

In a subsequent driving simulator laboratory experiment, 16 drivers retrieved traffic information on request. Among text-based systems, retrieval times using a graphic of highway buttons and a scrolling menu were less than those for a phone-style keypad method. Glance behavior to these displays involved several short glances. Response times for graphic systems were faster overall due to the reduced retrieval effort. Drivers typically made fewer, but considerably longer, glances to the graphic system displays.

Overall, the graphic of highway buttons was significantly preferred by participants, while the scrolling menu was least preferred. The standard deviation of lane position (in a driving simulator) increased by about 3-4 inches while using the traffic information systems.

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PREFACE

The United States Department of Transportation (DOT), through its Intelligent Vehicle-Highway Systems (IVHS) program, is aiming to develop solutions to the most pressing problems of highway travel. The goal is to improve traffic operations and reduce congestion, accidents, and air pollution from vehicles, by applying computer and communications technology to highway transportation.

If these systems are to succeed in solving the nation's transportation problems, they must be safe and easy to use, with features that enhance the driving experience. The University of Michigan Transportation Research Institute (UMTRI), under contract to DOT, has undertaken a project to help develop driver information systems for cars of the future, one aspect of IVHS. This project concerns the driver interface -- the controls and displays that the driver interacts with, as well as their presentation logic and sequencing. This is one of 16 reports that documents that work.

This project had three objectives:

- Provide human factors guidelines for the design of in-vehicle information systems.
- Provide methods for testing the safety and ease of use of those systems.
- Develop a model that predicts driver performance in using these systems.

Although only passenger cars were considered in the study, the results apply to light trucks, minivans, and vans. Another significant constraint was that only able-bodied drivers were considered. Disabled drivers are likely to be the focus of future DOT research. A complete list of the project reports and other publications is included in the final overview report (Paul Green, 1993, Human factors of in-vehicle driver information systems: An executive summary, Technical Report UMTRI-93-18, Ann Arbor, MI: The University of Michigan Transportation Research Institute).

To put this report in perspective, the project began with a literature review (Green, 1992) and focus groups to examine driver reactions to advanced instrumentation (Brand, 1990; Green and Brand, 1992). Subsequently, the extent to which various driver information systems might reduce accidents, improve traffic operations, and satisfy driver needs and wants, was analyzed (Green, Serafin, Williams, and Paelke, 1991; Serafin, Williams, Paelke, and Green, 1991). That analysis led to the selection of two systems for detailed examination (traffic information and cellular phones) and contractual requirements stipulated three others (navigation, road hazard warning, vehicle monitoring). Each system was examined separately in a sequence of experiments. In a typical sequence, patrons at a local driver licensing office were shown mockups of interfaces to determine driver understanding of the interfaces and preferences. Interface alternatives were then compared in laboratory experiments involving response time (Green and Williams, 1992), driving simulation, and other methods. The results for each system are described in a separate report. To check the validity of those results, several on-road experiments were conducted to obtain performance and preference data for the various interface designs.

In parallel with that work, UMTRI developed test methods and evaluation protocols, UMTRI and BBN developed design guidelines, and BBN worked on the development of the driver model. Many of the reports from this project are dated May, 1993, the completion date of the project when reports were to be delivered. However, the reports were drafted when the research was conducted, over two years earlier for the literature review and feature evaluation, and a year earlier for the laboratory research and methodological evaluations. While some effort was made to reflect knowledge gained as part of this project, the contract plan did not call for rewriting reports to reflect later tasks. Most of the research described here was completed two years before the report date.

This report examines potential approaches for displaying and retrieving detailed traffic information, one of the five systems selected for detailed evaluation. This system could help travelers avoid travel congestion. An abridged version of this research appeared in Paelke and Green (1992).

Acknowledgments

Several people have contributed to the research described in this paper. Of key importance are Marie Williams and Colleen Serafin, members of the UMTRI Human Factors Division research team involved with this project. Also, Daryll Hasse of the local secretary of state office (Pittsfield Township, Michigan) was extremely helpful in allowing us to spend numerous lunches and afternoons interviewing people while they waited in line. Finally, the authors would like to thank King Roberts of FHWA who has ably served as a contract technical monitor.

INTRODUCTION

Scope

The annual cost of traffic congestion in the United States is believed to be as much as 61 billion dollars (Serafin, Williams, Paelke, Green, 1991). The implementation of Intelligent Vehicle-Highway Systems (IVHS) should help reduce this waste of funds. One approach is to provide motorists with current traffic information throughout their trip. Given the proper information, many drivers may be willing to modify their routes or departure times to avoid delays due to congestion or incidents (Haselkorn and Barfield, 1990). Motorist information surveys have shown that the most important factor in route choice for daily commuters is travel time (Haselkorn and Barfield, 1990; Huchingson, McNees, and Dudek, 1977; Vaziri and Lam, 1983). For the average daily commute of 30-35 minutes, a delay of 16-18 minutes would cause drivers to divert to an alternate route (Haselkorn and Barfield, 1990; Allen, Stein, Rosenthal, Ziedman, Torres, and Halati, 1991).

Although the potential benefits of providing traffic information have been established, the most effective and safe methods for providing the information to drivers have not. For a traffic information system to be effective, it must be easy for drivers to understand and use while driving. To address usability concerns, traffic information system interfaces were developed using rapid prototyping software and evaluated by potential users.

The development of traffic information systems evolved through several phases of testing. Initial in-house development was followed by a study of usability and preference at a driver licensing office, which led to a laboratory simulation of five system prototypes.

Identification of Information Elements

To develop a driver interface, it was necessary to establish what information should be shown to the driver. Here, the focus was on a traffic information system for the near future. Four sources of information were used initially: (1) technical literature, (2) concept cars, (3) industrial liaisons, and (4) in-house expertise. These sources were supplemented by information drawn from focus group studies of driver information systems (Brand, 1990; Green and Brand, 1992). The relevant features for traffic information displays included: congestion, construction, freeway management, parking, traffic rules, vehicle access, and weather. The criticality of these features was evaluated based on the three scoring dimensions (Green, Serafin, Williams, and Paelke, 1991; Serafin, Williams, Paelke, and Green, 1991): (1) effect on accidents, (2) impact on traffic operations, and (3) driver needs, as described in the preface of this report. From those data, criticality scores were computed.

According to the criticality scores, the following information elements were highly ranked and considered for the traffic information system driver interfaces:

Distance to blockage

Location of congestion

Location where speed decreases

Congestion level

Travel speed (through problem area)

Length/area of congestion

Lane blockage

All of the elements did not appear independently; sometimes it was possible to aggregate elements. For example, by providing the specific location of the congestion by its beginning and end points, the length/area of the congestion was also provided. Also, showing the travel speed through an area was similar to providing a congestion level that would correspond to various speeds.

DEVELOPMENT OF POTENTIAL INTERFACES

In the design of traffic information systems, two issues were addressed:

1. How should drivers retrieve information?

2. How should traffic information be presented once drivers retrieve it?

Based on input from the research team members and the related literature, several retrieval methods and presentation schemes were identified. In considering the selection of interfaces for further development, emphasis was placed on examining a wide range of possibilities since a key aspect of this project was to develop a human performance model. For many of the retrieval procedures on display formats of interest, there were no existing simulator or on-road human performance data.

Several candidates were eliminated upon initial development attempts because they could not be presented in an easy or straight-forward manner. For example, thought was given to representing the level of congestion on a road by the width of a line on a road map. But three readily discriminable line widths (for three traffic levels) were difficult to show; the widest line was so wide that few map details could be shown. Therefore, this idea was abandoned and a guideline recommending not to use it was written. Similarly, showing the traffic speed on a road segment by having graphic elements move also proved infeasible because of the large area required to show several moving elements (dashed lines, car icons, etc.). This led to another guideline.

One of the interface design guidelines was that the display must be legible (Green, Levison, Paelke, and Williams, 1993). For the expected viewing conditions of traffic information displays, the required height was at least 0.25 inch. This value is only slightly larger than required by the Bond Rule, a human factors rule of thumb for computing character heights (Smith, 1979). In situations such as those found inside a car, where viewing time is limited, derived character sizes to achieve rapid reading are much larger than those identified from legibility threshold experiments (Boreczky, Green, Bos, and Kerst, 1988). Further, there was particular concern for making the display readable by older drivers.

Two visual information presentation schemes were considered, either text- or graphic-based. Three methods were examined to retrieve text-based traffic information, all using a touchscreen. Drivers could access information by pressing the desired highway on a static graphic map (Figure 1). Other text-based approaches included a scrolling menu somewhat similar to that in the TravTek interface (Figure 2) (Krage, 1991) and a phone-style keypad (Figure 3). In the text-based versions, a single information screen summarized each traffic problem (Figure 4).

The two graphic interfaces used a skeleton map of metro Detroit highways. Drivers pressed the area of interest to increase the level of detail viewed, up to three times (Figure 5). Areas with traffic problems were indicated using color coding (Figure 6), showing specific travel speeds (Figure 7), or combinations of speeds and color. The Detroit area highways (as opposed to a hypothetical network) were selected in order to examine the response of drivers who had some familiarity with the roads and traffic information being tested.

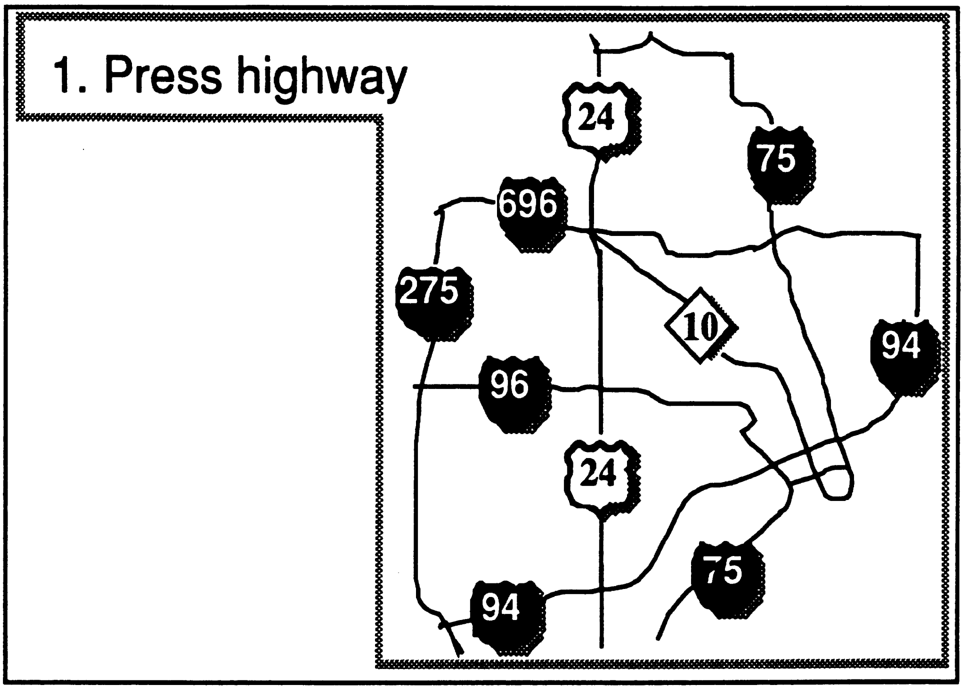


Figure 1. Text-based system with static graphic map using highway buttons as a retrieval method

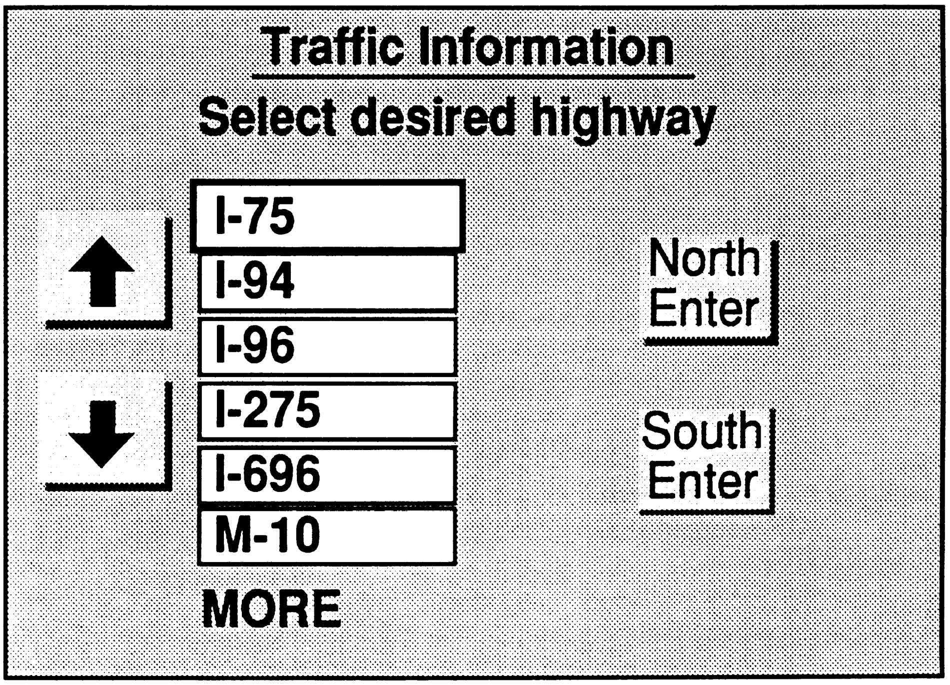


Figure 2. Text-based system with bidirectional scrolling menu

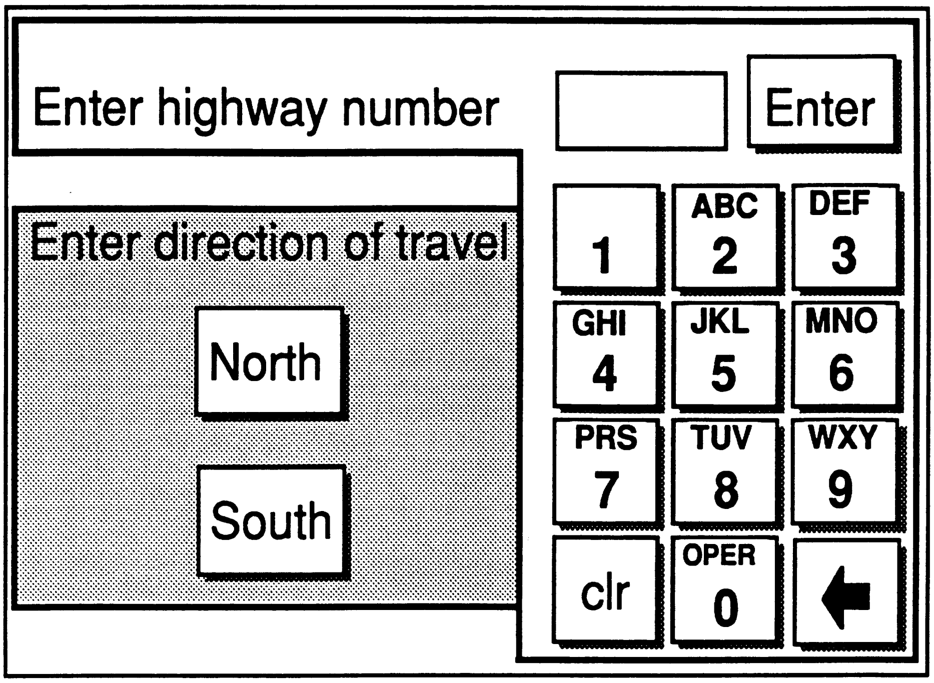


Figure 3. Text-based phone-style keypad retrieval method

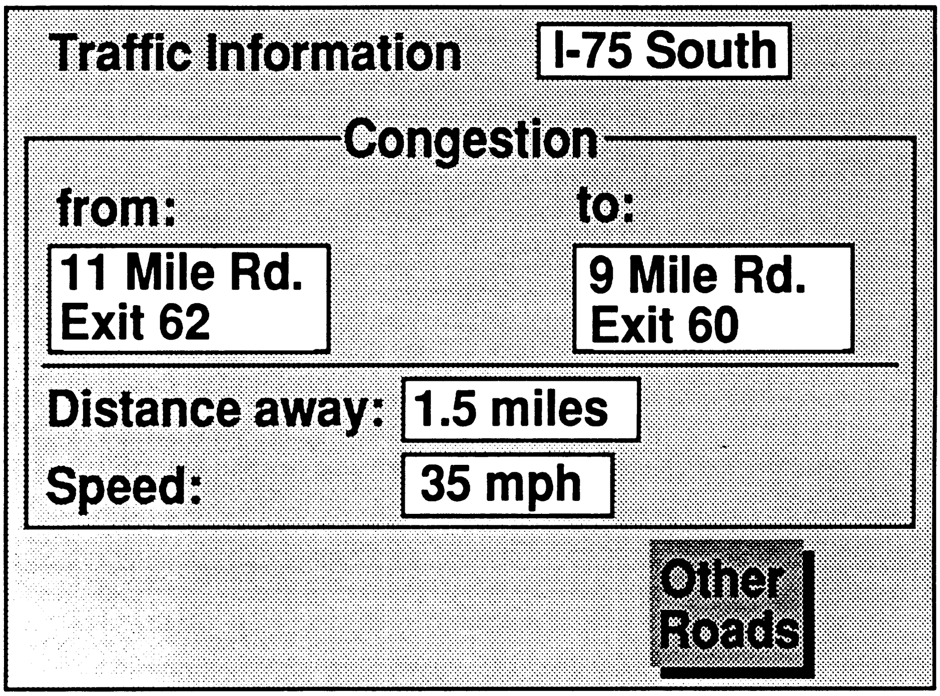


Figure 4. Preliminary text-based information screen

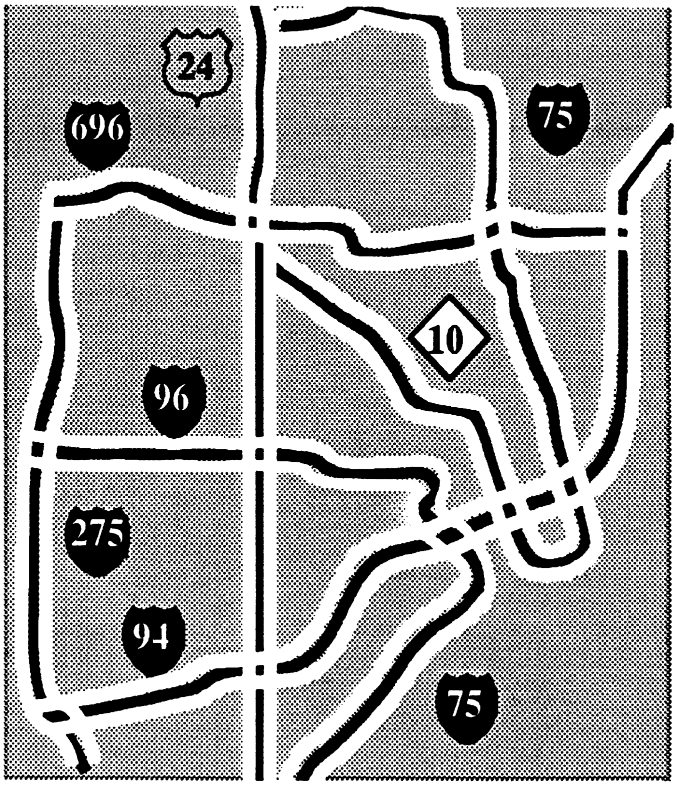


Figure 5. Skeleton map of the metro Detroit highways

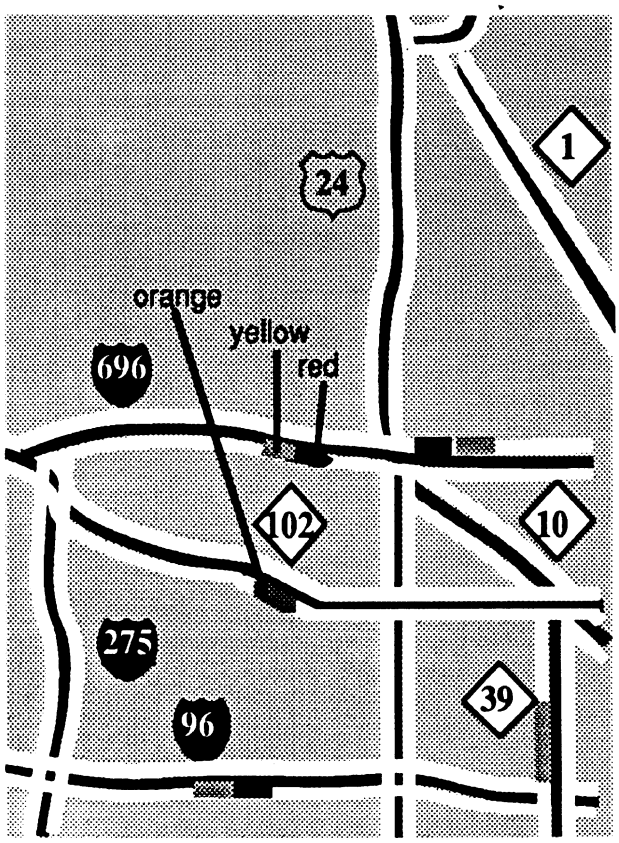


Figure 6. Graphic-based system showing next level of detail

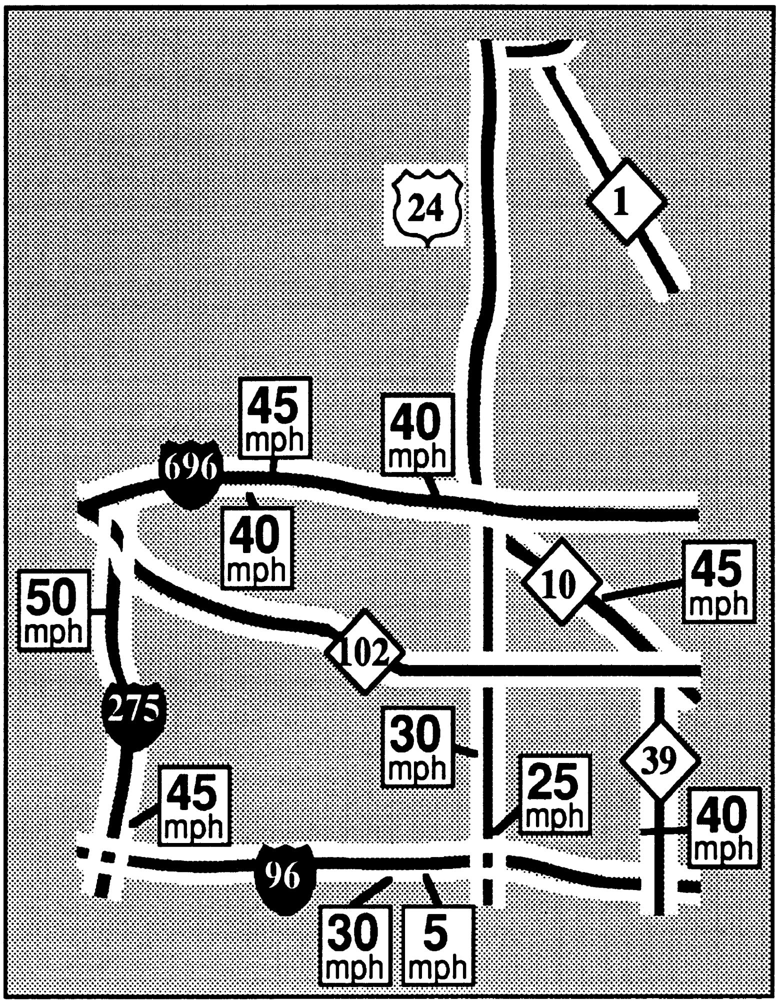


Figure 7. Graphic-based system with travel speeds

Application of Human Factors Methods from Human-Computer Interaction

To be able to design systems, calculation procedures are needed to predict performance of alternative designs. A class of models known as Goals, Operators, Methods, and Selection (GOMS) has been developed (Card, Moran, and Newell, 1983) to predict human performance with computer systems. GOMS provides estimates of the time required for people to complete routine cognitive activities. Two specific models belong in the GOMS category, the Model Human Processor and the Keystroke Model (Card, Moran, and Newell, 1983). The Model Human Processor is the most detailed. It contains ranges of estimates for perceptual, cognitive, and motor processor times, as well as storage capacities and decay constants for various memory systems as a function of storage format. In the Keystroke Model, elements are at a broader level, so several Model Human Processor elements could be combined to form one Keystroke Model element.

GOMS analyses include the following steps:

1. the goals and subgoals (e.g., goal = see if the path is congested; subgoal = see if the first section of the path is congested)

2. the operators to achieve a goal (e.g., get next task, use push and hold method to reach menu item, etc.)

3. the method or sequence of operators for accomplishing a task

4. the selection rules for carrying out the task (e.g., to get more detailed information using the graphic system, press on the desired highway)

The Keystroke Model has six basic parameters:

K The time to press a key or button, which depends upon the task conditions; In an office, the time (in seconds/character) is the inverse of typing speed.

P The time to point with a mouse to a target on a display. The time is assumed to be 1.1 seconds on average. For existing automotive driver interfaces, this parameter is unlikely to be used.

H The time (0.40 seconds) to move the hands to or from the home row of the keyboard or some other device. In the car, this element (recalibrated) might be the time to go to or from the steering wheel to a control on the dashboard.

D The time to draw Nd straight-line segments of length Ld cm (D = 0.9Nd + 0.16Ld). This element has no foreseeable automotive use.

M The time to mentally prepare for a task sequence, 1.35 seconds on average.

R The response time of a system, determined empirically.

Additional parameters may be added or modified to calibrate the model for specific applications.

The work carried out in this project is the first attempt to apply GOMS to automotive displays. Retrieval time predictions were developed for each of the interfaces using the Keystroke Model. The operators involved are mental operations (M), pointing (P), and button presses (B). A sample of the output from that analysis (for moving the selection box in the scrolling menu interface) is shown in Table 1. A comparison of predicted times for using the text-based systems and the costs of correcting an initially wrong highway selection are given in Table 2. The execution time differences between the unidirectional and bidirectional scrolling menus resulted from additional mental operations (M) needed to decide whether the up or down arrow should be pressed.

The GOMS model data must be applied to the automotive context with some care. The task times were drawn primarily from the psychological and human-computer interaction literature. In some cases, the psychological data implied that these tasks were performed as quickly and accurately as possible, not at a "normal" pace. Another complication was that the GOMS models were developed for single-task performance. However, the use of a traffic information system while driving will require time sharing between multiple tasks. While some work on time sharing has been done (John, 1990), the tasks have been discrete, unlike the continuous task of maneuvering a car.

Table 1. Sample of GOMS analysis for scrolling menu interface

Goal: Select the desired road		
Method: Move box directly to desired road		
Time (seconds)	Element	Steps
1.2	M	1. Think of direction you want box to move
1.1	P	2. Point to arrow corresponding to box movement direction
0.2	B	3. Press arrow button
		4. Report goal accomplished

Table 2. Comparison of selection and error times using GOMS model for scrolling menu interface (Preliminary analysis)

Input Interface	Time to select highway (seconds)	Cost of an error (seconds) (selecting wrong highway)
Unidirectional scrolling*	9.96+3.78(x-1)	3.78(n-1)
Bidirectional scrolling (Figure 2)	11.2+4.98(x-1)	4.98
Highway graphic (Figure 1)	7.56	3.78-6.2
Phone-style keypad (Figure 3)	5.68+d(3.78)	7.48(c)

where x = position of desired highway in list (1st, 2nd, etc.)
n = number of highways in list
d = number of digits in highway
c = number of digit corrections to make

* unidirectional scrolling menu was not evaluated in further testing

Despite these complications, GOMS models have potential for usability assessments of driver information system interfaces. As an example, the cost of an error among each of the text-based interfaces was computed. This comparison helped eliminate a unidirectional scrolling menu interface from further consideration because of the significant time required to correct a highway selection error (Table 2). To improve GOMS model estimates, calibration data (times, errors) should be obtained from people using real or simulated driver interfaces. It should be added, however, that even if the absolute values deviate from the real or simulated driver interfaces, the relative differences can be useful for comparing interface designs.

The screens for presenting traffic information to drivers were initially evaluated using the Tullis Display Analysis Program (Tullis, 1983). This is a PC-based program in which a display is entered as a text file and evaluated for its ease of scanning by the viewer. It was originally developed for CRTs showing fixed pitch characters on a 24 x 80 character display. The text is assumed to be structured or form-like (e.g., columns listing airlines, flights, departure times, and gates). Key factors include overall density (the fraction of the available character spaces filled), local density (the number of characters near each character), grouping of characters, and layout complexity. Unfortunately, this model does not consider the effects of color or highlighted text. Also, it could not accommodate graphical enhancements such as lines or boxes, which were used to organize the information on the traffic information screens. As a consequence, differences between screens were small and noninformative. However, in subjective evaluations of the initial screen designs, knowledge of the model parameters was useful, and the principles embodied in the model were used to develop design guidelines.

Quick Usability Tests

Most of the initial refinements of the interfaces were identified through quick usability tests performed continually throughout the development of the systems. These tests determined if people understood a certain aspect of the interface operation or information format, before it was completely developed into the prototype. Additionally, the tests proved to be quite helpful in formulating preliminary design guidelines. Input was typically obtained from a few people in the building (UMTRI) who were unaffiliated with IVHS research and development (e.g., clerks and secretaries from other departments). The questions addressed tended to be simple, and had a small impact on interface usability. Full scale experiments (using a driving simulator or on-road testing) for these issues would have been out of proportion given their degree of impact.

For example, when determining the format for the text-based information screens, five layouts (similar content, but with different justification, words highlighted, and graphic enhancements) were shown to seven people. The participants were told that the screens were for a traffic information system. They were asked to describe what the screens were telling them. After identifying the content of the screens, the participants' preferences and suggestions for improvement were recorded. In general, people preferred displays that used highlighted text to identify the main information points. Also, they tended to prefer screens that had graphic enhancements (e.g., lines and boxes to separate different information types).

A similar quick experiment was conducted to determine what gestures people used for changing the level of detail on a touchscreen graphic display. One issue was the gestures people would use for zooming in and out. Approximately 10 people were shown two maps, a map similar to Figure 5 and a second, more detailed map. They were asked what motion they would make to get to the second map (pushing the highway, pushing the highway sign, pushing the general area of interest, etc.). Due to the absence of a gesture stereotype, it was decided to run the experiment again with a grid superimposed over the map (dividing the map into four quarters). When this display was shown, all subjects pressed within the grid area. It was therefore determined to provide a grid on the global-level map, in order to avoid ambiguities for zoom-in commands. For the zoom-out command, no gestures were indicated (people said they wanted a button instead). Consequently, the idea of a gesture-based interface for this operation was eliminated.

Other quick usability tests were conducted to determine how well people could understand the graphic representations of traffic information. This helped refine the initial color-coded and travel-speed screens.

The main advantage to the quick usability approach was the immediate feedback gained on whether people understood the designs. Also, it was easy to obtain subjects because the only real criteria for selection was that they be unfamiliar with advanced driver information systems. However, the disadvantage to this approach was that the small sample size provided no quantitative performance data on which to base decisions. However, for the kinds of decisions to be made, the informal testing carried out was appropriate, as well as quick and inexpensive.

DRIVER LICENSING OFFICE TESTING

Purpose

Once the interfaces were developed and refined to a suitable level of functionality, they were taken to a Michigan secretary of state office (where driver licensing, vehicle registration and similar activities are conducted) to receive input from a wide variety of licensed drivers. The purpose was to gain insight on the understandability of each interface and drivers' preferences for the presentation of traffic information. The following questions were addressed:

1. Can drivers understand the use of traffic coding schemes on maps?
2. How do drivers interpret various color coding schemes?
3. What method(s) of showing traffic information on electronic maps do drivers prefer?
4. What commands would drivers use to access greater/lesser levels of traffic information detail on electronic maps?
5. Do drivers understand text-based methods of selecting highways for obtaining traffic information?
6. What text-based method for selecting highways do drivers prefer?

Method

Twenty drivers (8 men and 12 women) at the Pittsfield Township (Michigan) secretary of state office participated. The drivers ranged in age from 20-59 years, with a mean age of 36. Twelve of the participants had at least a college degree. Most of the drivers were native English speakers.

Color copies of computer screens were shown to subjects as they waited in line. The experiment took between 12-15 minutes to complete. The screens were developed on an Apple Macintosh using SuperCard or Canvas software.

Testing of the graphic-based interfaces was conducted first. The experimenter showed the subject a map of the major highways in the metro Detroit area, with a scale of 8 miles/inch. (See Figure 5). Subjects were given a hypothetical driving situation (e.g., "You are traveling west on I-696 toward I-275") and asked how they would access more detailed information.

Next, the understandability of different schemes for graphically showing traffic information was tested. For each of the schemes shown in Table 3, the subjects were asked what information the screen was giving them and where they felt traffic was the worst. They were also asked the meaning of each color, and the approximate travel speed they would expect in each colored area. All of the screens shown were for the northwest portion of metro Detroit highways (scale = 4 miles/inch). Screens were shown involving only color-coded information (Figure 6), only travel-speed information (Figure 7), and both travel-speed and color-coded information. The screen size, character sizes, and level of detail were representative of an in-vehicle display.

Table 3. Schemes tested for the graphic display of traffic information

Design	Speed Shown	Color Coding
1	no	*color scheme I* yellow = slower than normal (41-54 mph) orange = much slower (16 - 40 mph) red = stopped/crawling (0-15 mph) (white = "normal" traffic)
2	no	*color scheme II* green = above speed limit yellow = slow (31 mph - speed limit) red = very slow (0 - 30 mph) (white = "normal" traffic)
3	yes	none
4	yes	*color scheme I*
5	yes	*color scheme II*

After subjects gave their interpretation of all five schemes, they were asked to rank them in order of preference. Next, they were asked how they would access more detailed information for a specific traffic problem shown on the display. They were then shown the most detailed level of information, which gave specific locations of the problem based on nearby exits (Figure 8). After interpreting this screen, they were asked how they would tell the system to show them the earlier screen. (This was done by showing them the screens to avoid biasing their language selection.) Subjects chose from commands provided or suggested their own.

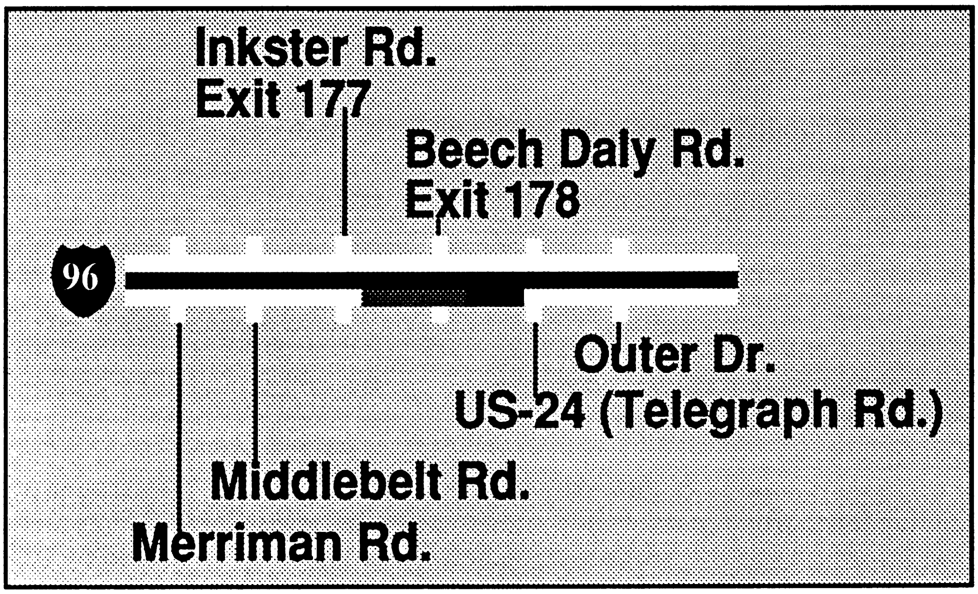


Figure 8. Graphic-based system at most detailed level

The testing of textual displays for traffic information was less extensive at the secretary of state office, as the dynamic nature of these displays that could not be captured on paper. (Many of the buttons in Figures 1 and 3 appear only after the highway is entered.) Subjects were shown input screens for three potential text-based systems: a scrolling menu (Figure 2), a graphic of the highways (Figure 1), and a phone-style keypad (Figure 3). The displays shown to subjects were in color. Subjects were asked how they would select a highway using each system, and then ranked the three systems based on their preferences.

Results and Discussion

Both color schemes were understood by most of the participants, as shown in Table 4. The orange coding in the first color scheme was unclear to 35% of the drivers (they either had no idea, or thought it explicitly indicated a construction area). The second color scheme was more consistently understood. In general, the implication of red = stop and yellow = caution was quickly assumed by the drivers tested.

Table 4. Understandability of color schemes for representing traffic information

Scheme	Understandability	
Color scheme I	Color	Speed
yellow (40-50 mph)	90%	85%
orange (20-39 mph)	65%	60%
red (0-19 mph)	95%	80%
Color scheme II		
green (over 55 mph)	75%	85%
yellow (25-50 mph)	90%	85%
red (0-24 mph)	90%	90%

*note: in both schemes, white indicated "normal" traffic

The understandability of each graphic display was measured by whether the participants gave the intended interpretation of the color and estimated speed. Multiple answers were accepted, as long as they conveyed the general idea (e.g., yellow = slow, caution; red = stopped, heavy, jammed). Responses that were different from the intended meaning implied that the driver did not understand the coding scheme (e.g., orange = bus routes; green = lawn crew, etc.).

Subjects preferred the second color scheme (green-yellow-red). The most preferred graphic interface showed both color-coded congestion and actual travel speeds on problematic links, as indicated in Table 5. According to a Kruskal-Wallis test of ranks, the differences among them were significant ($H(4) = 37.8$, $p < 0.001$). It should be noted that to determine their interpretation of the color coding, a key was not provided on the map. This may have led to their preference of having the travel speeds included on the display. In the next phase of laboratory testing, a key was provided to address this issue and the desire for such became a guideline.

Table 5. Preferences for showing graphic traffic information

	Mean rank	Scheme	Design
Best	1.90	Color II (green-yellow-red) with speeds	5
	2.35	Color I (yellow-orange-red) with speeds	4
	2.75	Color II (green-yellow-red)	3
	3.75	Color I (yellow-orange-red)	2
Worst	4.25	Speeds	1

The results of the text-based systems indicated that drivers preferred the interface that used a static graphic with highway buttons (signs) of the metro highways (Kruskal-Wallis ($H(2) = 24.9$, $p < 0.001$). However, the methods they used to enter the highway of interest varied. The majority (55%) pressed the highway sign (I-275) followed by the desired direction (south enter). Preferences of the remaining subjects were split among four methods of input: pressing south enter, pressing south enter and then the highway sign, pressing west enter, and pressing on the lower (south) portion of the line representing the highway. The interpreted use of the scrolling menu was much more consistent, with only 15% suggesting something other than using the arrows to scroll along the menu. The keypad entry interface was least preferred but had consistent results. Most (85%) would press only the numbers corresponding to the highway, while 15% would press the letter ("I" for Interstate) followed by the highway number. The results of the static tests of the traffic information interfaces from the secretary of state office were used to further develop the prototypes for laboratory testing.

LABORATORY TESTING OF THE INTERFACES

Purpose

While the previous experiment indicated clear preferences for traffic information system interface formats, the driver performance data were limited. This experiment collected the performance data desired. The following issues were addressed:

1. Will drivers be able to use traffic information systems effectively to determine upcoming traffic problems?
2. Which type of interface (graphic or text) is easier for drivers to understand?
3. Which type of interface (graphic or text) has the best response time?
4. Of the graphic formats, is it best to use color coding with a key, or color coding with approximate travel speeds?
5. Of the text formats, which is best for retrieving traffic information?
6. Do drivers prefer a text-based or graphics-based traffic information system?
7. What is the number of eye fixations required to read the various screens?

Method

Driver Interface Alternatives Examined

Based on the input of patrons at the driver licensing office, five traffic information system interfaces were developed further. Three of these were text-based systems, using the retrieval methods that were successfully understood in the previous study. Two graphic-based interfaces were also developed further. From the previous study, it was determined that a revised color-coding scheme should be used (green = freely moving traffic at or above the speed limit, yellow = slower traffic at 30-54 mph, and red = very slow/stopped traffic at 0-29 mph). This scheme eliminated the use of white roads for "normal" traffic by using green for all traffic at or above the speed limit. One graphic system showed traffic information by using only the color coding (including a key), and the other by using the color coding combined with estimated travel speeds on congested links.

Five methods for retrieving traffic information were tested. Detailed traffic information was assumed to be available for major (limited-access) highways. Highways in the metro Detroit area were used, rather than creating a fictitious network or using the highways of a city for which test participants were unfamiliar, to allow for more realistic testing conditions. Three of the system designs were text-based and used a common text screen to describe the traffic problem. The two graphic systems showed the traffic problem as a red or yellow segment of the highway. A brief description of each system follows.

A bidirectional scrolling menu (referred to as arrowmenu throughout the study) was one entry method for retrieving text-based traffic information. The major highways in metro Detroit were listed in increasing alphanumeric order, as shown in Figure 9. Throughout the trials, the selection box always started at the top (I-75). To select the highway of interest, the subject used the arrow buttons to move the box. For the highway selected, the appropriate directions of travel appeared on the right side of the display (north-south; east-west). Therefore, to receive traffic information for a particular highway, the subject needed to select the highway (using the arrow buttons) and press a button for the desired direction of travel.

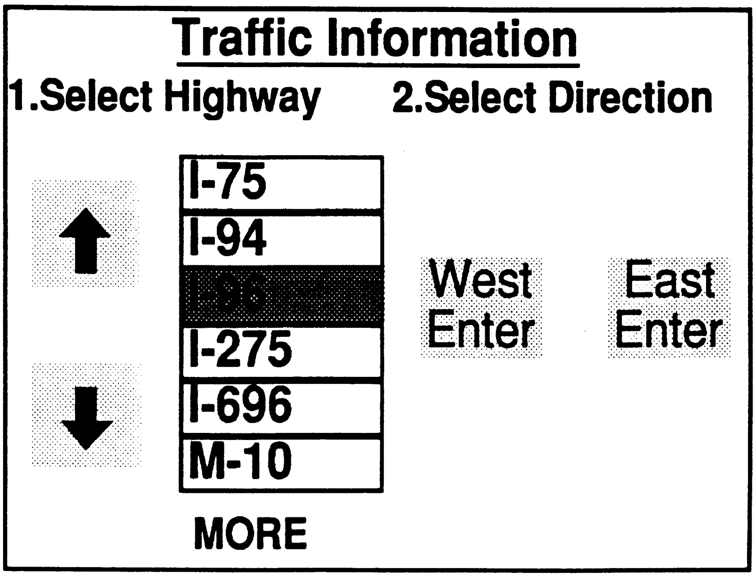


Figure 9. Bidirectional scrolling menu (arrowmenu) interface

The interface in Figure 10 used a static graphic of metro Detroit highways for highway selection. Each highway was represented by a graphic button (in the shape of the highway shield). A subject would press the button for the highway of interest. Once a highway was pressed, the corresponding directions of travel for that highway would appear. The subject would then press a button corresponding to the direction of travel.

Using the phone-style keypad interface (Figure 11), the highway of interest was selected by entering the digits of the highway (for example, to enter Interstate 94, a user would press the "9" and "4" buttons). When the desired highway appeared in the display, the subject pressed the "enter" button to show the directions of travel that corresponded to that highway. The participant then selected the desired direction of travel.

The three text-based systems all used similar traffic information screens to inform drivers of traffic problems. A sample of a text-based traffic information screen is shown in Figure 12. Screens indicating no traffic problems were also provided.

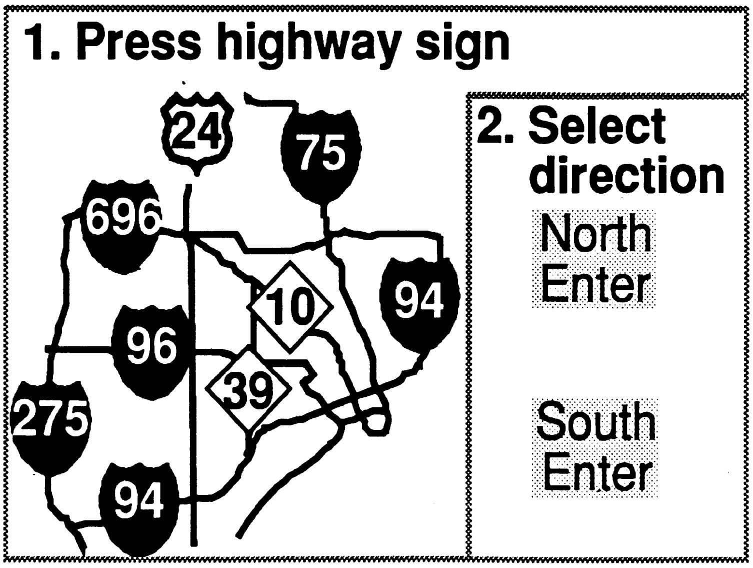


Figure 10. Static graphic of Detroit highways used for selection (graphicmenu)

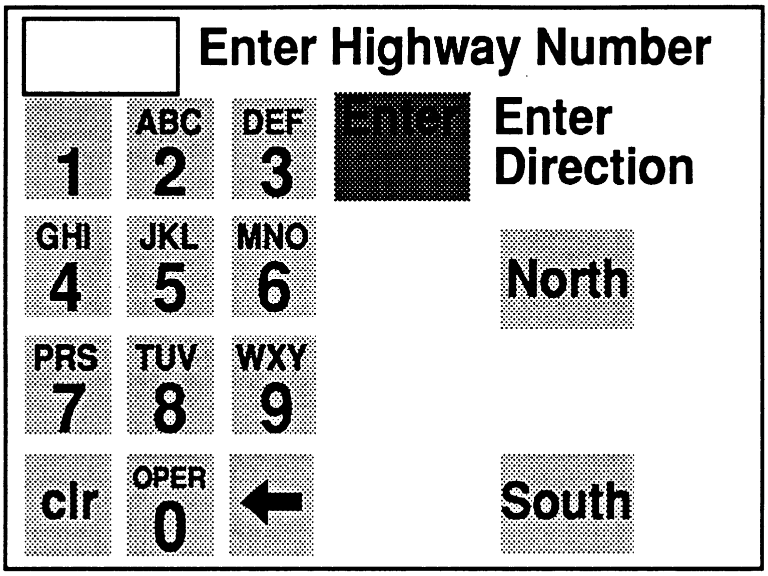


Figure 11. Phone-style keypad used for highway number entry

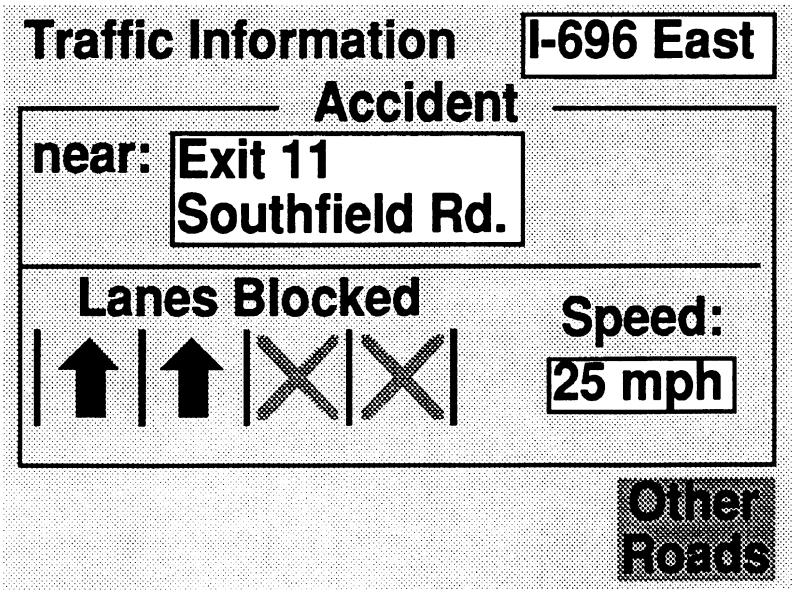
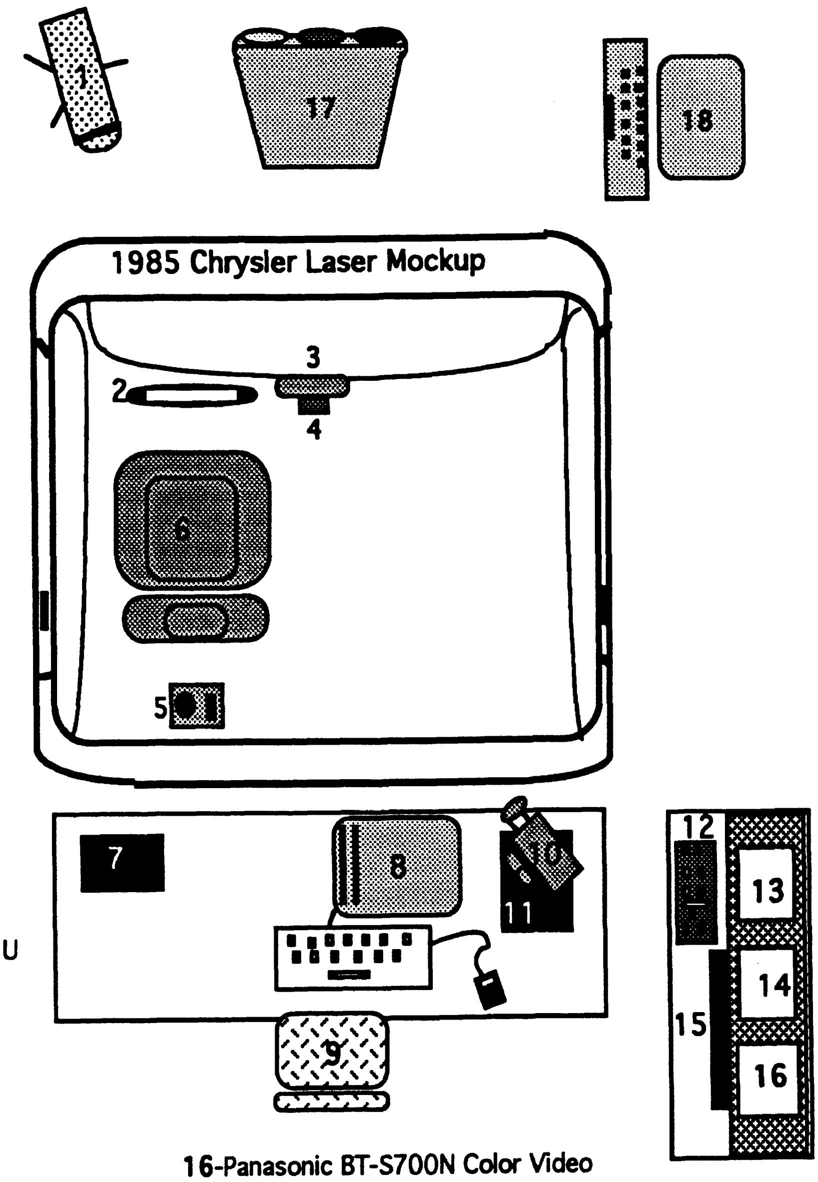


Figure 12. Text-based traffic information screen

Test Equipment and Software

The interface prototypes were developed using SuperCard on a Macintosh IIcx computer with a Daystar PowerCache accelerator. Each "button" on the interfaces was programmed to record response time. The experiment was conducted using a driving simulator consisting of an A to B pillar vehicle mockup, a video projector, and an NCR PC-8, 80286 compatible computer. The systems appeared on a 5-inch Panasonic LCD display mounted on the upper-middle console of the mockup. A touchscreen was created for the display by modifying a Microtouch Macintosh SE touchscreen controller and an Unmouse input device. (The Unmouse is a small touchpad with a clear faceplate that is approximately the same size as the LCD display.) Participants used the modified touchscreen as an input device for the traffic information systems. A custom response box (for responding "yes" or "no" to the question of traffic problems) was located directly below the touchscreen display. All of the equipment used in the experiment is shown in Figure 13.

The driving scene appeared as a single-lane road at night (similar to Figure 14), on which the driver was instructed to keep the vehicle centered. The velocity of the simulator was constant, so the driver's task was to properly steer while using the traffic information systems. The simulator was connected to the Macintosh computer via a serial port. This allowed flags to be sent to the driving simulator output files identifying the tasks (on the traffic information system prototypes) occurring while driving, synchronizing the two data sets.



1-RCA B/W Camera TC1030/H;
Lens, TC1803;
Controller, TC1430;
Intraspot Lens 16-160MS

2-Steering Wheel

3-Panasonic LCD display

4-Custom Response Box

5-Realistic Minimus-7 Speaker

6-Driver's Seat

7-Realistic SA-10 Solid State
Stereo Amplifier, 31-1982B;
Realistic SA-150 Integrated
Stereo Amplifier, 31-1955

8-Macintosh II cx with Daystar
Powercache Accelerator;
Apple Keyboard M0116;
Apple Mouse A9M0331

9-Experimenter's Seat

10-JVC Color Video Camera S-100U;
Canon TV Zoom Lens 16-160MM;
JVC Electronic Viewfinder VF-C511U

11-Camera Stand

12-JVC KM-1200 Color Special
Effects Generator

13- Sanyo VM-4209 B/W Monitor

14-Sanyo VM-4509 B/W Monitor

15-Panasonic AG-6200 Video Tape
Recorder

16-Panasonic BT-S700N Color Video
Monitor

17-NEC Data Projection System,
Model DP-1200SH

18-NCR PC-8 Computer

Figure 13. Diagram of laboratory equipment

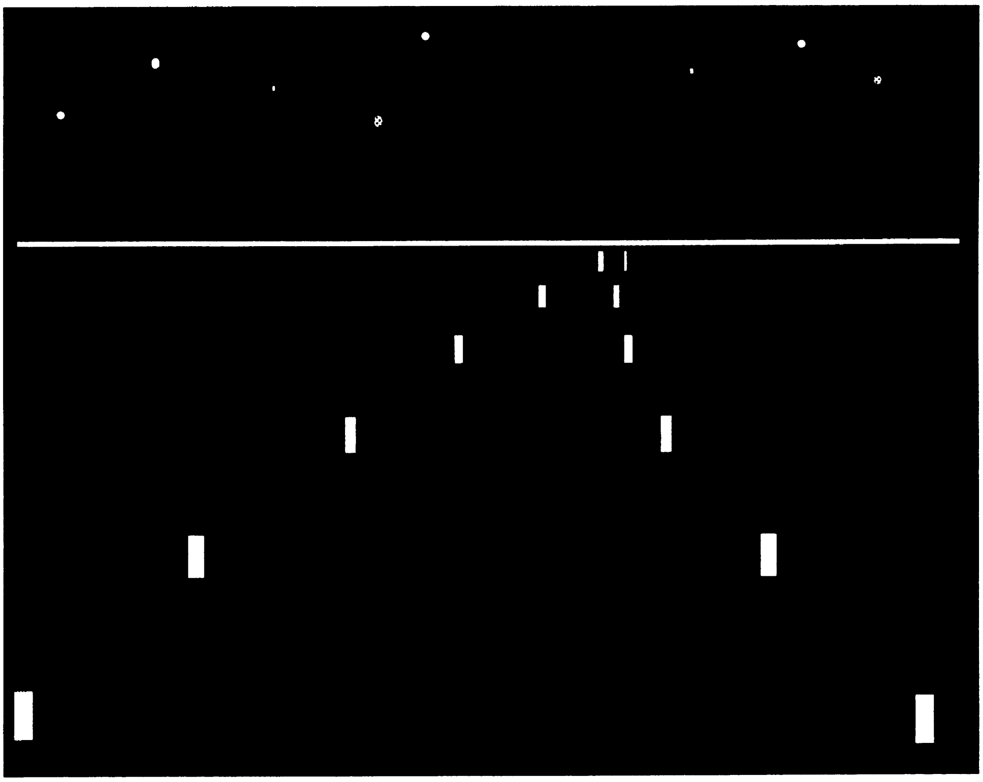


Figure 14. Nighttime driving scene of the simulator

Test Protocol

The experimenter briefly explained the study to the participants before getting their consent and collecting biographic data. The biographical and consent forms are provided in Appendices A and B. Participants were seated in the vehicle mockup throughout the study. The experiment was explained using the instructions provided in Appendix C, and then participants practiced using the driving simulator (typically for 2 minutes).

Participants were told that they would use five different traffic information systems to determine if there were any traffic problems on a given highway. An auditory cue (e.g, "Are there any traffic problems on I-75 North?") and accompanying visual cue (Figure 15) were given to begin each trial. The participant's task was to use the system to retrieve traffic information for that particular highway.

Each individual traffic information system interface design was described to a participant as he or she was about to use it. While the system appeared on the display, the experimenter explained how it functioned. (In many cases, the participants guessed how it would work before being told.) After the explanation, participants were given three practice trials without the driving simulator, followed by a practice trial while driving the simulator.

For each of the five interface designs, there were five test trials. The driving simulator was used during all trials when data were collected. After entering the highway of interest, participants would view the information screen(s) and respond to the question by pressing a "yes" or "no" button, located directly under the display. If a "yes"

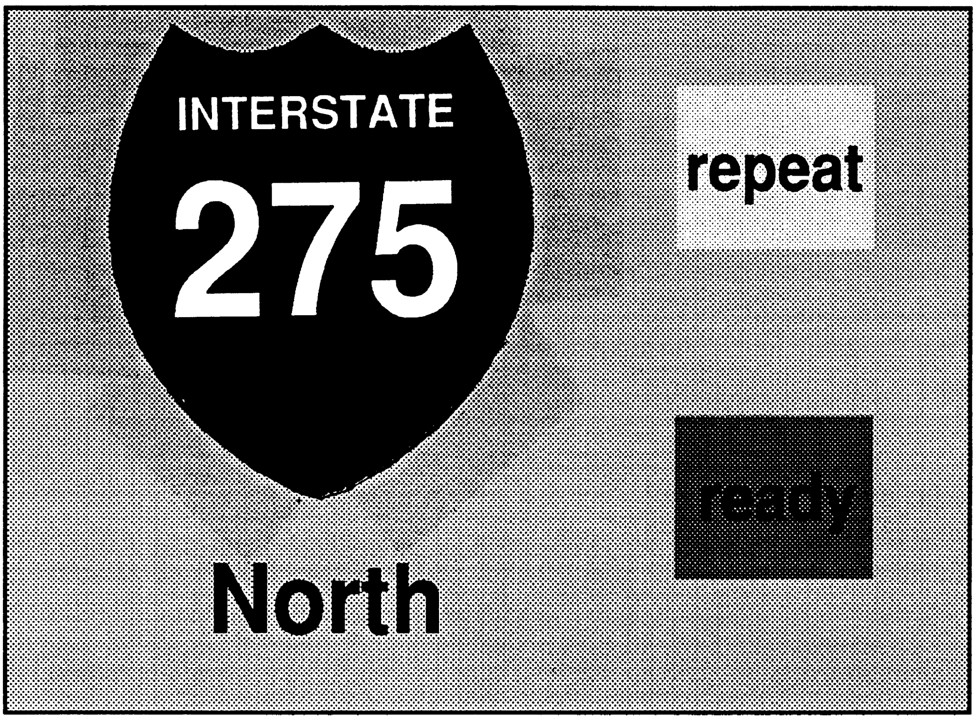


Figure 15. Sample visual cue screen

response was given, they were asked to identify the location of the problem by giving the street name or exit number of the affected area. An intertrial period of 15 seconds was given after responding, during which the traffic information screen would be blank and the subject would concentrate only on driving the simulator.

After all five interface designs were used, the participants exited the mockup and were asked to rank the systems in order of their preference. They were then thanked and paid for their time.

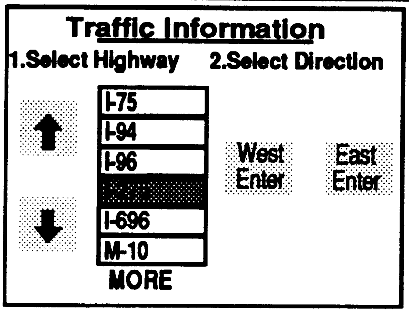
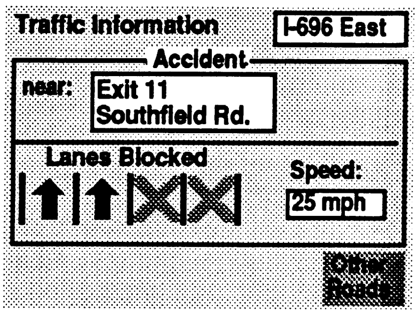
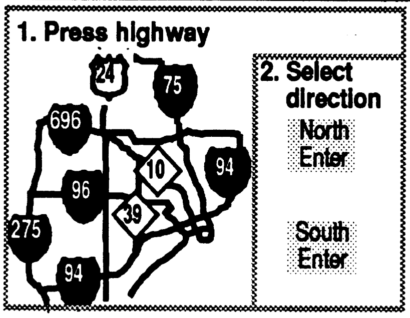
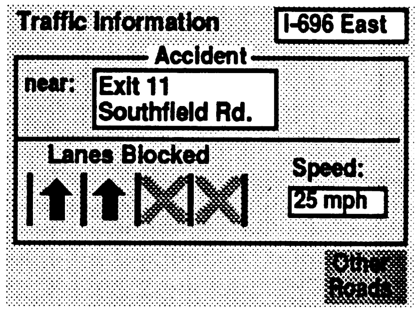
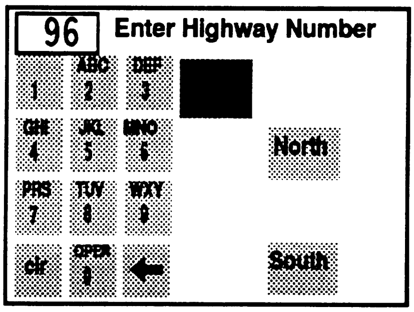
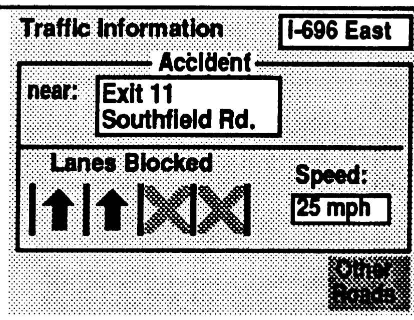
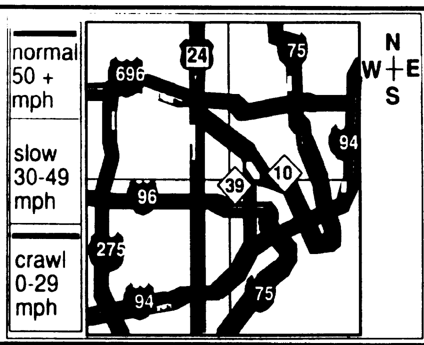
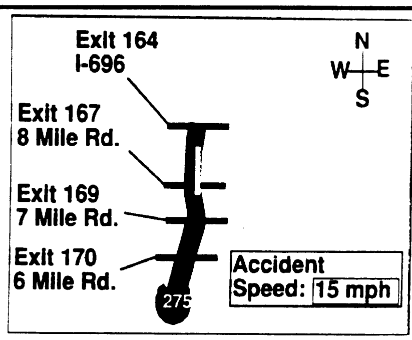
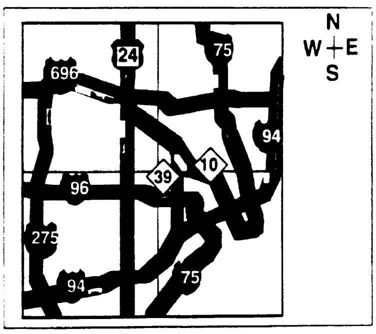
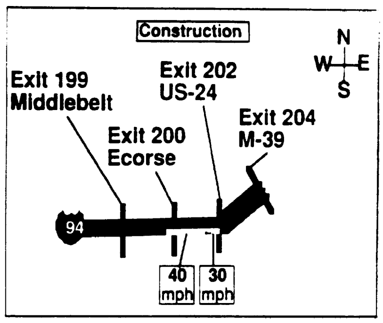
Test Participants

Sixteen drivers (8 men and 8 women) ranging in age from 20-77 years were involved in this experiment. They were divided into two age groups, younger (20-35 years old, mean = 23 years) and older (over 60 years old, mean = 72 years). Twelve participants were at least familiar with metro Detroit highways and 13 felt comfortable using maps. None had experience using a navigation system. In addition, seven of the younger participants had used a touchscreen before, whereas none of the older participants had ever used one. Each participant was paid $15 for the 1 to 1.5 hour session.

Results and Discussion

The traffic information prototypes were designed to collect response times for every button pressed. This data helped measure the task time required for requesting and responding to traffic information for specific highways. A summary of the five traffic information interface designs is provided in Table 6. The various traffic information retrieval and presentation methods were also evaluated using lane position data from

Table 6. Summary of Traffic Information System Interface Designs

System Interface Name	Main Level Screen	Detailed Information Screen
Scrolling menu Use arrows to move highlighted box within list of highways. Traffic information provided by text screen.		
Static graphic highway map Select highway by pressing corresponding button (represented by highway symbol signs). Traffic information provided by text screen.		
Phone-style keypad Enter digits of highway using the number pad. Traffic information provided by text screen.		
Map with key Identify traffic problems by color coded areas on skeleton map of metro area highways.		
Map with speeds Identify traffic problems by colored areas on skeleton map of metro area highways, enhanced by estimated travel speeds on more detailed levels.		

the driving simulator. A brief analysis of eye-glance frequency was conducted to assess the visual demand of each traffic information interface.

Task Time Analysis

Three of the five traffic information interfaces examined in this study provided text-based information. The format of the traffic information was similar for all text systems, however, the method of entering the highway of interest was different. Entering the highway of interest and the desired direction of heading was the first subtask in using the traffic information systems. An analysis of variance indicated that the time required to request traffic information for a particular highway was significantly affected by the driver's age ($F = 40.7$, $p < 0.001$), as indicated in Figure 16. Over all three text-based systems, older drivers required 37% longer to enter the same highways as younger drivers.

The method of input (scrolling menu, static graphic, or phone-style keypad) also had a significant main effect on highway entry time for text-based interfaces ($F = 28.5$, $p < 0.001$). The static graphic interface, for which the user pressed a highway sign graphic and a corresponding direction of heading, had the fastest entry time (4.5 seconds and 5.9 seconds for younger and older drivers, respectively). The keypad method required the most time (6.2 seconds for younger and 8.3 seconds for older drivers), probably because a longer sequence of button presses was needed.

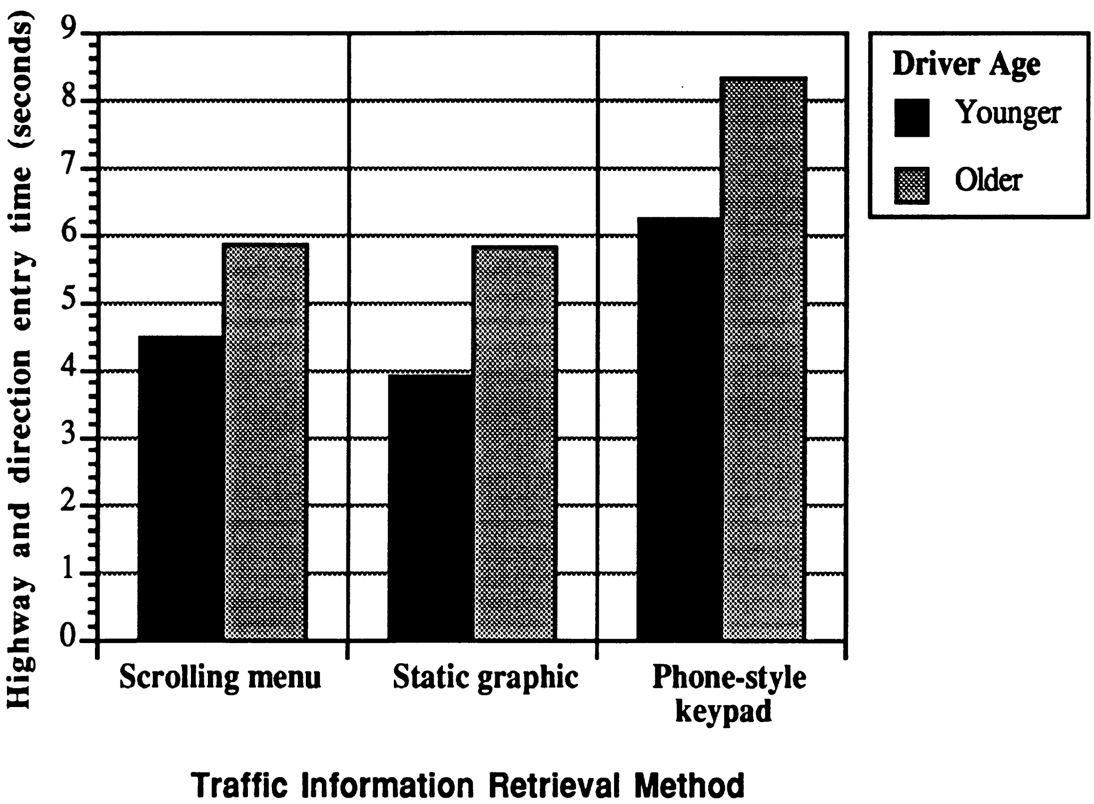


Figure 16. Effect of interface design and driver age on text-based system highway entry

The total time required to determine whether a traffic problem existed on a given highway is shown in Figure 17 for all five prototypes. Note that it was not necessary to specifically enter a highway when using the graphic-based methods (map with key and map with speeds); therefore, it is difficult to make direct comparisons between the graphic and text-based methods. The age effect was most noticeable with the highly graphic-dependent map with key interface design. This required drivers to find the highway of interest on a skeleton map and identify traffic problems using a color-coded key. Older drivers were able to detect traffic problems 2 seconds faster if an estimated travel speed was provided instead of the coding key. The improvement in response time for providing specific speeds over a color-coding key was less noticeable (0.4 seconds) for the younger drivers.

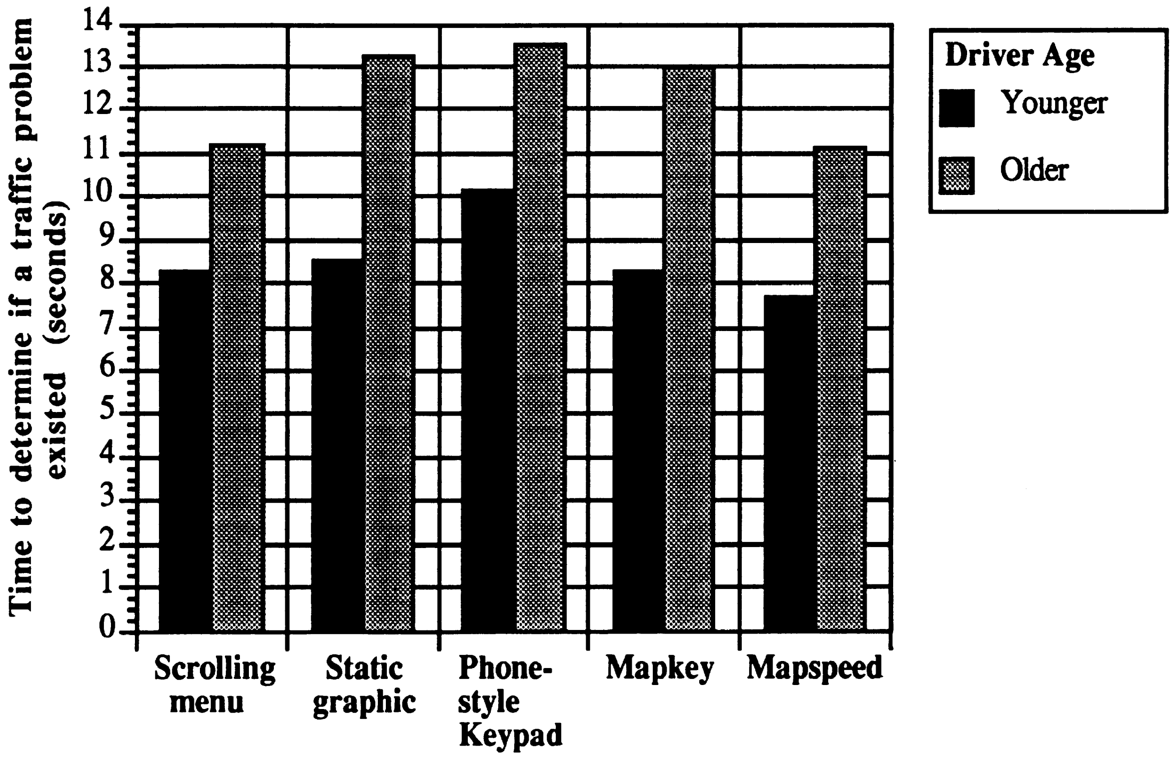


Figure 17. Task times to identify if a traffic problem existed

The time to decide if a traffic problem was presented varied depending on whether a problem existed or not. For the text-based systems, it took slightly longer for a "yes" response (when a traffic problem actually existed) than a "no" response. This difference was not statistically significant.

An opposite trend was found with the graphic map interfaces. For this presentation of traffic information, it took significantly less time to respond to the initial screen if a traffic problem was present (7.39 seconds for younger and 11.34 seconds for older drivers) than if no problems were shown (9.1 seconds for younger and 13.6 seconds for older drivers).

Although response times for the graphic map enhanced with approximate travel speeds (map with speeds) were faster than with the color key alone, the difference was not statistically significant. As noticed in Figure 17, age had a highly significant main effect ($F = 30.9$, $p < 0.001$) on graphic map task time, with older subjects requiring an average of 50% more time to identify traffic problems displayed graphically than younger subjects.

Driving Performance

Lane position data were collected at 10 Hertz on the driving simulator. The data were later grouped into five-second segments of baseline driving (no use of traffic information systems) and driving while using the traffic information systems. The variance of these segments was used to evaluate driving performance.

Maintaining lane position in the driving simulator was significantly affected by use of the traffic information systems while driving. The standard deviation of baseline driving when not using any in-vehicle systems was 4.6 inches for younger and 4.9 inches for older drivers. As shown in Figure 18, older drivers' steering behavior was more dramatically affected by traffic information system use than younger drivers'.

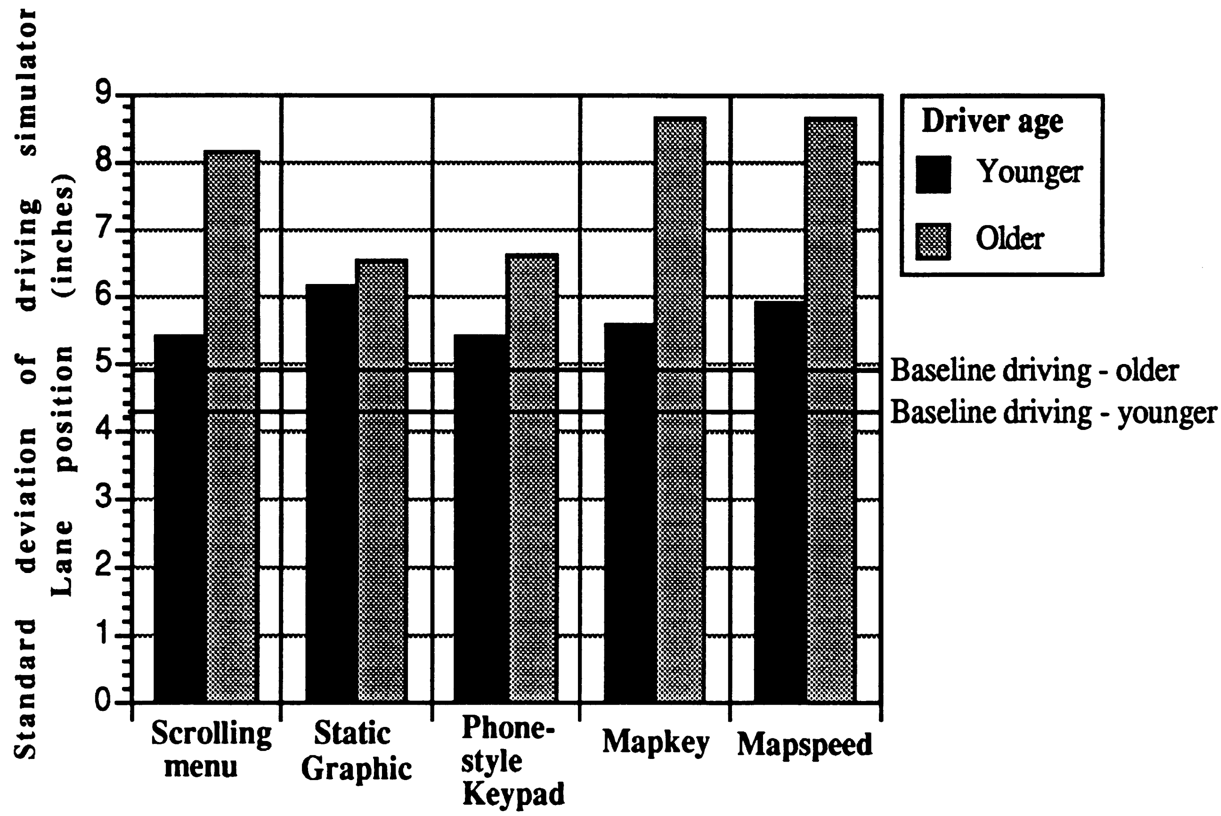


Figure 18. Standard deviation of driving simulator lane position

Lane position standard deviations for younger drivers using the traffic information systems ranged from 5.4-6.1 inches, with the highway graphic menu (text-based) having the worst impact on simulator driving performance. The older drivers' lane position was more varied, ranging from 6.4-8.8 inches. It appears from Figure 18 that the graphic-based systems were the most visually demanding and attention demanding for the older drivers. In contrast, their best driving performance was with the highway graphic menu, where information was obtained by pressing the highway sign button and reading a text screen. There was no evident correlation between driving simulator performance and traffic information system use time.

Although the differences in lane position were small, the driving condition was fairly simple (gentle curves, no traffic, simulated cruise control); therefore, even slight performance differences should be interpreted as meaningful.

Eye Fixations

Eye fixations were recorded by a video camera facing drivers. A comprehensive frame-by-frame eye position analysis exceeded the scope of this portion of the project. To gain insight into the eye fixations of typical subjects in the experiment, the videotapes of four subjects (one younger female, one younger male, one older female, one older male) were analyzed to estimate the frequency and duration of glances to the traffic information display while using each of the five interfaces. Table 7 shows the average number of glances for the last four trials of each system interface. For the text-based systems, the glances were separated into glances while entering the specific highway, and glances viewing the actual traffic information screen. For the graphic systems, the number represents all glances made to the main screen before making the traffic response.

Drivers typically made several short (less than 1.5 seconds) glances to the text-based menus and information screens. The graphic highway menu had the least number of glances, while the scrolling menu appeared to be the most visually demanding. While using the graphic interfaces, drivers made fewer glances to the display; however the glances were observed to be considerably longer (over 2 seconds). Participants were more captivated by the graphic screens, as was indicated somewhat by their driving simulator performance.

Table 7. Number of glances to the traffic information display used to determine if a traffic problem existed

Subject	Scrolling menu	Static graphic	Phone-style Keypad	Map with key	Map with speeds
younger female	6 + 2	3.75 + 1.75	6.25 + 2.25	3.75	2.75
younger male	5.75 + 1	3 + 1	6.25 + 1.3	2.5	2
older female	8 + 1.3	2 + 1	4.25 + 1	2.5	2.75
older male	7.5 + 1	2.75 + 1	6.5 + 1	2	3.25

Note: values for text-based systems are divided into glances to the highway entry screen + glances to the traffic information screen.

Preferences

Preference data were collected during a short debriefing following the study. A Kruskal-Wallis Analysis indicated a significant preference within the text systems and overall systems for the text-based graphic highway system ($KW(4) = 11.6$, $p = 0.02$). The ranked order of preferences is shown in Table 8. Between the two graphic-based systems, there was no significant preference for providing a color-key versus more specific estimates of travel speed.

Table 8. Ranked preferences for all traffic information system interfaces

Rank	System	System type
1	Static graphic	Text-based
2	Phone-style keypad	Text-based
3	Map with speeds	Graphic
4	Map with key	Graphic
5	Scrolling menu	Text-based

It should be noted that the preferences may have been influenced by the speed of the system prototypes, particularly with respect to the scrolling menu interface. Delays occurred because the computer used was not fast enough to handle all the data to update the screen. The experimenters and subjects found it necessary to wait for the system to scroll to the next entry after pressing a button. However, this would not occur with a production interface.

OVERALL CONCLUSIONS

The methods described in this paper have been useful for developing prototype interfaces to test the usability of traffic information systems. It should be noted that the rapid prototyping tools used (SuperCard on a Macintosh IIcx) resulted in traffic information interfaces that operated very slowly. This problem was most noticeable with the scrolling menu interface. This speed was further reduced when a video board with NTSC output was used to display the screens on the 6-inch LCD monitor. Although accelerator boards have been acquired to help alleviate this problem, frustrations with the slowness of SuperCard remain. As improved hardware and software are released over the next 2-3 years, this problem will diminish. Despite its slowness, SuperCard provided an easy-to-use graphic environment for developing and evaluating the interfaces.

The authors have long advocated the use of prototyping tools for interface design (Green, Boreczky, and Kim, 1990). While simulated driver interfaces did prove to be easy to modify, they took considerable time to develop, sometimes as long as a month, but usually several weeks. However, prototyping still took much less time than it would to develop real interfaces.

The use of quick usability tests were quite helpful for developing the traffic interfaces from scratch. The continuous line of feedback helped ensure that people other than engineers could understand and use the systems. It was helpful to eliminate confusing or cumbersome interfaces (such as line widths and dynamic icons) early on, so that efforts could be directed toward interfaces that were more understandable (such as color coding or travel speeds). These prototypes were also quite helpful in formulating design guidelines. Clearly, the methods of testing and the sample sizes were not traditional. If one shows an interface to six reasonably typical drivers and they cannot understand it at a first glance (and the design specifications say they should), then there is no need to test another 94 drivers to arrive at a commonly accepted sample size and confirm the problem.

Interviewing drivers at the secretary of state office was also beneficial. The subjects helped identify items that were confusing (e.g., the orange color coding), and often suggested other information they would like to include on the interfaces (e.g., color keys, alternate routes). The results of this phase of testing indicated that drivers easily understood three levels of traffic indicators. For color coding, red (for stop or hazard), yellow (for slow or caution), and green (for freely moving or go) were quickly understood by drivers. Using orange to indicate a traffic level between yellow (slow) and red (stopped) was ambiguous to over a third of the drivers, and is therefore not recommended. The feedback gained from the secretary of state testing was helpful for improving the traffic information system interfaces before conducting more detailed laboratory testing.

The laboratory study indicated that drivers were able to learn and use all five of the traffic information systems tested. For the text-based systems, the static graphic highway button method was the fastest for entering a highway in order to retrieve traffic information. This was not surprising since this method required the least number of button presses for highway entry. The scrolling menu and keypad had slower times due to the greater number of button presses or steps involved in the highway entry procedure. Performance using all of the systems was significantly affected by the age of the driver.

The frequency of eye movements to the displays was indicative of the complexity and time required during highway entry. Among text systems, the static highway button graphic interface had the least number of glances to the display during highway entry. The number of glances to the scrolling menu and keypad were both considerably higher, indicating a greater visual demand.

The graphic systems had a faster time for determining if a traffic problem existed on a given highway. This was likely due to a difference in functionality between the graphic and text-based systems. With the graphic systems, a driver was able to identify the existence of a traffic problem from the main screen. To gain more detailed information regarding the problem, it was necessary to "zoom in" (change screens) two times; however, the basic issue of traffic problem occurrence could be detected on one main screen. In contrast, the text-based systems required the highway of interest to be entered first before any traffic information was provided.

Unfortunately, the main screen of the graphic systems was more complex due to increased amount of information present, which caused longer glances to the display, and decreased driving performance for older drivers. This problem would intensify if more roads were added to the coverage area for traffic monitoring.

Drivers had a clear preference for the highway button graphic interface. The keypad, although the slowest for determining traffic problem occurrences, was ranked second. There was no significant preference differences for the two graphic-based systems which were ranked third and fourth. The last place ranking of the scrolling menu should be partially attributed to the response lag of the SuperCard prototype, which inflated the rate of errors and frustration during its use.

Based on the findings of the laboratory study, several recommendations or guidelines can be made for future designs of an independent traffic information system. Since most systems will require multiple screens for entering and displaying the information, it would be helpful to provide cues at the main level as to whether traffic problems existed on the various highways in the coverage area. While the highway button graphic design may become cluttered with the inclusion of nonlimited-access arterials, a similar approach of providing buttons for each highway could be used without the accompanying road network graphic. Highways with traffic problems could be given different colored buttons than those with normal traffic conditions. This would allow drivers to quickly determine if their road(s) of choice were clear, or if an alternative route should be considered. More detailed information could be provided upon pressing the specific highway button.

The method of selecting a highway should be chosen to minimize the number of button presses. This would reduce entry time. To reduce the visual demand of the display, attention should be given to the complexity of information on the screen. The complexity of the text screens used in this study was higher than optimal, since drivers usually needed more than one look at the display to determine the details of the problem.

Finally, it should be noted that the traffic information systems examined in this study were defined to be independent, stand-alone systems. Actual implementation of traffic information into an in-vehicle display would likely be in conjunction with a route guidance or other IVHS component. If the traffic information system was integrated with an intelligent system, the current location and destination of the vehicle would be known, therefore traffic information could be provided automatically throughout the journey. Regardless, the results concerning display format apply to all types of traffic information systems and the retrieval method recommendations apply to drivers who may manually examine traffic for other routes.

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APPENDIX A

Biographic Data Collection Form

University of Michigan Transportation Research Institute
Human Factors Division

Biographical Date: ____

Name: ______________________________

Male Female (circle one) Age: ________

Occupation: ____________________

Education (circle highest level completed):

some high school	high school degree
some trade/tech school	trade/tech school degree
some college	college degree
some graduate school	graduate school degree

Other: ______________________________
(If retired or student, note it and your former occupation or major)

What kind of car do you drive the most?

year: ________ make: ____________ model: ____________

Annual mileage: __________

Have you ever driven a car with a navigation system? yes no

Does your car have a Head-Up Display (HUD)?
(If you don't know what it is you probably don't have one.)

yes no ----> Have you ever **driven** a car with a HUD? yes no

How comfortable are you using maps?

very comfortable | moderately comfortable | neutral | moderately uncomfortable | very uncomfortable

How many times in the last six months have you used a map?

0-2 times | 3-5 times | 5-8 times | 9-12 times | 12 + times

How familiar are you with Metro Detroit highways?

very familiar | moderately familiar | neutral | moderately unfamiliar | very unfamiliar

Have you ever used a touchscreen? yes no

TITMUS VISION: (Landolt

1	2	3	4	5	6	7	8	9	10	11	12	13	14
T	R	R	L	T	B	L	R	L	B	R	B	T	R
20/200	20/100	20/70	20/50	20/40	20/35	20/30	20/25	20/22	20/20	20/18	20/17	20/15	20/13

APPENDIX B

Participant Consent Form

Evaluation of Traffic Information Systems

Participant Consent Form

We are working on a system to show drivers traffic information. A well designed system can be used at a glance, so people can concentrate on driving. Responses from typical drivers such as you, will help identify the best way to show this information. While sitting in a driving simulator, you will respond to a small touchscreen display located inside the car. This display will show highways and traffic problems. A computer will record how long it takes you to discover the problem and how many errors you made. We may videotape this session, but only if you allow us. We will not release any identifying information, so your responses will remain confidential.

The experiment takes about 1-1/2 hours for which you will be paid $15 dollars. You may take a short break between system testing if you would like. If you have any problems completing this experiment, you can withdraw at any time. You will be paid regardless.

I have read and understand the information above.

____________________________ __________________
Print your name Date

____________________________ __________________
Sign your name Witness (experimenter)

It is okay to videotape me: yes no (circle one)

APPENDIX C

Laboratory Experiment Instructions
Traffic Information Study Subject Instructions

Prior to arrival of participant:

Make sure there are blank consent forms, bio forms, support voucher, and money for payment.

- Make sure two power strips near Mac and power strip near projector are on
- Set up hood, make sure they line up with computer lane markers
- Make sure computer lane markers match with foamcore strips
- Turn on driving simulator (computer, monitor, big plug, power button on simulator, power button on remote, RGB 1)
- Turn on video equipment
- Make sure volume box is on (adjust using top speaker knob)
- Make sure gray pluggie is plugged in
- Turn on monitor in car
- Turn on MicroTouch (**CALIBRATE IT!! Check that it's good!**)
- Set up lighting in front of projector
- Check sound system, plug speaker into volume box

Complete as much of the bio form as possible.

When participant arrives:

Are you ____? Hello, my name is _______ and I am one of the experimenters working on the traffic information study. Before we get going I would like to note this experiment takes approximately 1 1/2 hours and you will be paid 15 dollars for your time. If you would like to visit the rest room, now would be a good time to do so. Also smoking is prohibited in this building, so please refrain from doing so.

Go into lab. Flip "Experiment in Progress" sign over.

The purpose of this experiment is to determine the best way to present drivers with traffic information. Since people will be driving while obtaining traffic information, the system must be easy-to-use so it won't distract the driver from driving. The results of this study will be used for designing systems for use in future vehicles. Since you will be driving those vehicles, your opinion is important.

Before we start, there is some paperwork to complete. First, you need to sign this official consent form the university requires us to give you, which basically repeats in writing what I just said.

Have participant sign consent form.

Also, we need to know a little more about you.

Fill out bio form with subject.

Test subjects vision. Make sure both eye switches are on.

Have participant sit in buck.

You will be driving the UMTRI driving simulator as you obtain traffic information. Please position yourself as if you were driving. Are you comfortable? Would you like the seat moved at all?
Adjust seat if necessary.

I am going to turn off the lights now.
Turn out lights.

The driving scene is similar to nighttime where you'll see road markers on the edge of the lanes. The road scene looks like this (turn on simulator). Try to stay in the middle of the road at all times. Please try driving on it for a couple minutes to get used to it.
Run Driving Simulator for 2 minutes. Ask if comfortable driving the simulator

IP test

As you drive the simulator, you will be asked if there are any traffic problems on specific highways. You will answer this question by using the traffic information systems that will appear on this display (point to it) **and responding "yes" or "no" with the buttons on the gray box** (point to it). **The "yes" and "no" buttons activate a computer-recorded voice which you will hear thru this speaker (point to the speaker). If there are traffic problems (which means you answered "yes") you will be asked to describe where the traffic problem exists - you can just tell me an exit or street that it is near.---**

There will be five different systems that you will use. The traffic information systems use a touchscreen, so it responds to any pressure you make on it.

Have you ever used a touchscreen before?
Refer to bridal registry and other examples

You will use the touchscreen system to determine if there are any traffic problems and to move from screen to screen. Here is a short practice session to help you use the touchscreen and the buttons on the gray box to obtain traffic information.
Answer questions.
Run TI tutorial

After they finish the tutorial, explain that you will show them each system before they use it.

To begin each system
Run driving simulator
Launch each system directly.

When "block completed" session comes up,
Quit (command-Q) traffic info system
quit driving simulator

Start recording videotape

CHECKLISTS FOR EXPLAINING EACH SYSTEM TO SUBJECTS

Text-based systems

Arrowmenu
• You will be prompted to obtain traffic info for a certain highway and direction *(Start practice)*
• Highways arranged increasing alphabetic numbers so Interstates come first, then Michigan, then U.S.
• Two arrows move blue box up & down each highway (*subject tries for I-96*)
(note that the system responds slowly)
• Direction that highway runs in are shown (*want East*)
• Press "Enter" for the direction you're interested in (*subject tries*)
• Traffic information screen appears - tells whether or not there is a traffic problem
• If make mistake, press "Other Roads"
• Use gray box to answer (your response will be repeated by the box)
• If there's a problem then will prompt to tell where the problem is, just give the street or exit number that problem is close to. In this case, there's a problem
• Pay attention to road and keep the car within its lane
• If can't recall what highway you're looking for, just ask
• Questions before beginning practice?
• Start driving simulator, give examples (*subject must press go back*)
I-94 East, I-75 South, M-39 South
• Comfortable using system? If yes, start test; if no, give more examples
• When the blank screen comes up, we've started.
If you press NEXT (before you want to).
Command-M (message box)
type in: put 0 into mcnt
press return
close the message box
(now when you press NEXT, it will start)

Graphicmenu
• Prompted to obtain traffic info for certain highway and direction (*Start practice*)
• Select highway by pressing button with highway number on it (*subject tries a few buttons, end with I-696)*
• Choice of direction appears, press "Enter" to select (*subject tries, want East*)
• Traffic information screen appears - tells whether or not there is a traffic problem
• If make mistake, press "Other Roads"
• Use gray box to answer (you will hear your response)

• If there's a problem then will prompt to tell where the problem is, just state street or exit number that problem is close to. In this case, there's a problem
• Pay attention to road and keep the car within its lane
• If you forget what highway you're looking for, just ask
• Questions before beginning practice?
• Start driving simulator, give examples (*subject must press go back*)
M-10 North, I-96 West, I-75 North
• Comfortable using system? If yes, start test; if no, give more examples
• As soon as blank screen appears, we've started.

Keypad
• Prompted to obtain traffic info for certain highway and direction (*Start practice*)
• Select highway by entering highway number into keypad, only DIGITS!
• Example: for I-275, type in "275"(*subject tries*)
note that system responds slowly
• Once highway number is in the display, press "Enter"
• If you make a mistake, press clear or delete
• Choice of direction appears, press direction they want (*subject tries, want South*)
• Traffic information screen appears - tells whether or not there is a traffic problem
• If make mistake, press "Other Roads"
• Use gray box to answer
• If there's a problem then will prompt to tell where the problem is, just state street or exit number that problem is close to. In this case, there's a problem
• Pay attention to road and keep the car within its lane
• Questions before beginning practice?
• Start driving simulator, give examples (*subject must press go back*)
I-696 West, M-39 North, I-94 East
• Comfortable using system? If yes, start test; if no, give more examples
• As soon as blank screen appears, we've started.

GRAPHIC-BASED SYSTEMS

Mapstack (Colors with key)
• Prompted to obtain traffic info for certain highway and direction (*Start practice*)
• Map is of main highways in Metro Detroit
• Explain 3 strips (green, gray, green) on highway on screen
• Always traveling on right side of the road. For example, if on right of the median of I-275, you are heading North, but if left of the median of I-275, you are heading South - use compass to guide
• Explain blocks of color on highway and color key
• Three levels of detail
• First level is divided into 4 areas. Get to second level by pressing on the area (quadrant) that you're interested in. To get to the third (final) level of detail, press on the traffic problem (red or yellow lines).
• Press "Go back" to view previous level of detail
• May be able to tell from first level if there is a traffic problem. See if there's a traffic problem on the highway and direction asked. Use the gray box to answer the question (*In this case, I-94 East, subject tries*)

As soon as you know there if there is a problem, press "yes" or "no" on the gray box
- If press "yes", you'll be asked to describe the location of the traffic problem. To do this, you need to get to most detailed (third) level of information. Just give the street name or exit number that problem is close to.
- If there is no traffic problem, the highway will be all green
- If there is a traffic problem, the highway will have yellow or red areas.
- Pay attention to road and keep the car within its lane
- Questions before beginning practice?
- Start driving simulator, give examples (*subject must press go back*)
  I-96 East (yes)   I-75 North (yes)   I-696 East (yes)
- Comfortable using system?. If yes, start test; if no, give more examples
- As soon as blank screen appears, we've started.

<u>Maps&Speeds</u> (Colors with speeds)
Same as above but explain that specific traffic speeds are given for areas with problems. Want I-75 South

Other examples for practice: I-275 North (yes)   M-10 North (no)
I-94 West (yes)   I-94 East (yes)   I-696 East (yes)

Ask subject which text system they preferred (show pictures of system with arrows, keypad system, and graphic system)
Ask subject which graphic system they preferred (show pictures of system with color bars on side and system with the speeds posted)

Ask subjects to rank all five systems (1 = best, 5 = worst).