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Human Factors Engineering the TravTek Driver Interface

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ABSTRACT

The TravTek vehicle provides an information-rich multifunction environment for the driver, necessitating extensive teamwork in human factors engineering the displays and controls for efficient and safe operation. Example map and text screens are presented.

TravTek is an advanced driver information system that will be field tested and evaluated in a year-long program in Orlando, Florida, in 1992. The TravTek program has been described by Rillings (1*) and the TravTek vehicle by Krage (2). This paper highlights the human factors effort in engineering the TravTek driver interface.

Drivers who use the TravTek-equipped vehicles in Orlando will have an information-rich environment in the vehicle. Functions available in the vehicle include navigation information, route guidance, real-time traffic information, and information on local services and attractions. As shown on the Main Menu screen (Figure 1**), drivers can choose to enter a destination, browse through information on local services and attractions, browse through maps of the local area,

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*Numbers in parentheses designate references at end of paper.

**All screens in the figures are reproduced from an operational simulation of the visual driver interface produced on a Macintosh II computer using Supercard software.

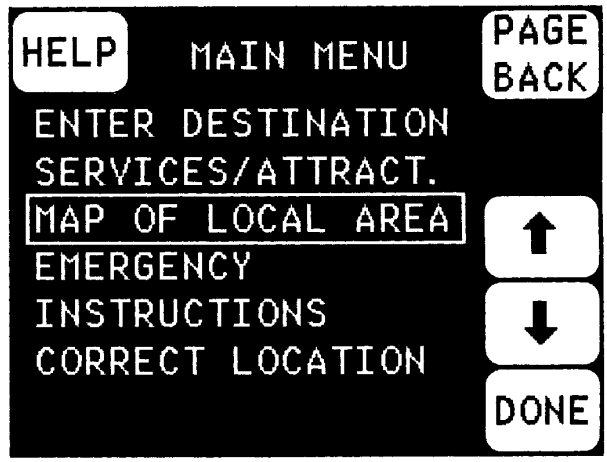

Figure 1. The Main Menu Display

request emergency services, go through tutorial instructions, or correct the location of their vehicle on the map display.

This richness of information and multiplicity of functions has the potential for causing information overload and operational confusion for the driver. Therefore, human factors engineering of the information displays and controls has been a team priority from the early conceptual stages of the project. The intended users of the field test system--travelers and local residents--will have minimal opportunity for training in system use. Throughout design and development, an overriding consideration has been to make the system as easy to learn and easy to use as possible.

Early design concepts visualized a display screen and controls tailored to the characeristics of the

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information to be displayed and actions to be input by the driver. However, since TravTek was to be a limited-edition system for operational field test purposes and not a mass-produced production system, economic considerations dictated that an existing display and touchscreen system already integrated into the vehicle instrument panel be used as the major driver interface. The 1992 Oldsmobile Toronado includes such a system as an option and was therefore selected as the vehicle for the operational field test.

The CRT and touchscreen are mounted in the instrument panel in the area usually occupied by radio and climate control assemblies, as shown in Figure 2. The color CRT has eight colors available, and the infrared touchscreen has 25 touch-sensitive areas arranged in a five-by-five matrix. The commercial map databases available for use did not contain all of the information that might be desirable to communicate to the driver. However, within the context of these system constraints, the driver interface for TravTek has been designed to increase usability and learnability, decrease information density and distraction, and respond to individual differences in driver preferences.

Generally accepted tenets of human factors engineering for user interfaces were the starting point for the organization of information on the display screens. Principles that were followed include consistency of placement of types of information from screen to screen, grouping of related information, consistency of nomenclature, conservative use of color, and coding by both shape and color.

Figure 2. The Instrument-Panel-Mounted Display Screen

Anthropometric considerations and the range of driver ages dictated that a large character size be used on the displays. High legibility is needed to permit the driver to glance at the display screen and grasp the displayed information quickly. A special high-legibility font was designed to accomplish this objective.

Display of map information, and especially of route guidance information, constituted the biggest design challenge. Most prior research points out what not to do rather than what to do for map displays. For the driving mode, it is important to reduce the density and distraction quotient to minimize eyes-away-from-the-road time. Laboratory studies were undertaken to determine some of the most important factors in map usage.

Another area for laboratory investigation was the nomenclature to be used for the touchscreen controls and menu items. Because of the character size and the touchscreen characteristics, labels on the soft keys could contain no more than two rows of four characters each, and menu items also have a space restriction. A series of studies identified labels that are understandable to untrained users, given the size constraints. Multiple ways of displaying traffic information visually were investigated to arrive at a set of symbols that are clear and do not conflict with each other.

Although there is no consensus on the use of maps and touchscreens while driving, the TravTek philosophy has been to proceed with caution. This conservative approach led to a distinction between functions available to the driver only in a pre-drive mode (while the car is in Park) and functions available while driving. Only navigation and traffic information, which support the driving task, are available when the car is in Drive.

In addition, to reduce the necessity for the driver to look at the display screen while driving, auditory displays using coded tones and synthesized voice messages were added to the design to supplement the visual information. The decision was made early in design to eliminate the use of touchscreen keys while the car is in motion, and to allow the driver to make system inputs only through

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activation of steering wheel buttons while driving. Steering wheel button inputs include enabling or suppressing synthesized voice for location information, traffic information, and route guidance; requesting the repeat of voice messages; changing the map display; and correcting the vehicle position on the map.

PRE-DRIVE FUNCTIONS

The pre-drive functions are wholly visual, and numerous touchscreen interactions with the system are available. The Enter Destination function allows the driver several choices of how to enter a desired destination, as shown in Figure 3. Like many of the other top-level menu screens, the driver scrolls a choice box to the desired menu item by touching the up and down arrow keys, then touches the "DONE" button.

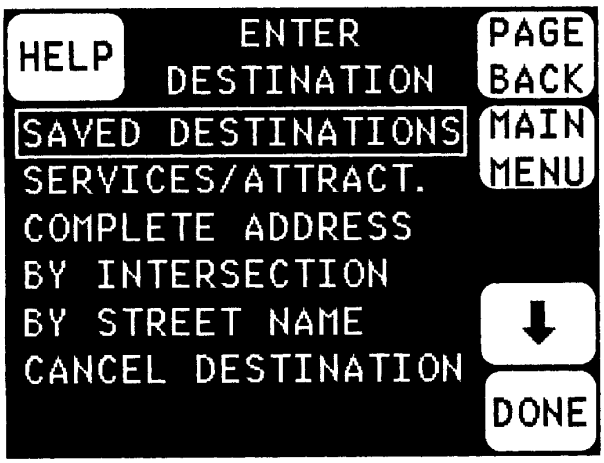

Figure 3. The Enter Destination Menu

Selection of a destination entry method such as "Saved Destinations" brings up another type of screen, as shown in Figure 4, on which the driver can make a choice by touching a soft key adjacent to a two-line descriptor.

Another pre-drive function allows the driver to browse through local services and attractions. The top-level menu for this function, shown in Figure 5, allows the driver to select places to stay, including hotels/motels and campgrounds; things to see and do; places to eat; other services; and city facts.

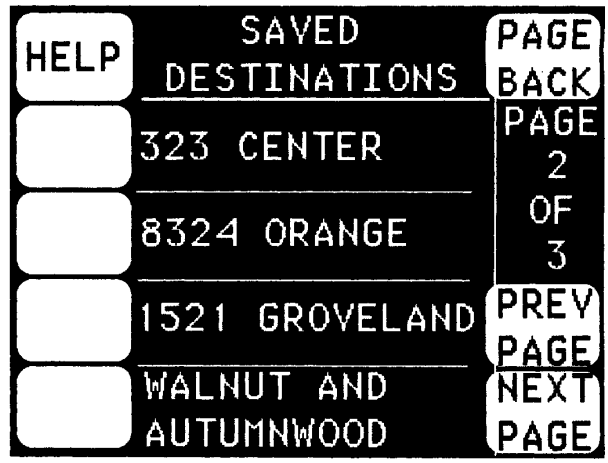

Figure 4. The Saved Destinations Screen

Still another pre-drive function is browsing through maps of the local area. When this function is selected from the Main Menu, the screen displays a map showing the location of the car in a heading-up orientation, as shown in Figure 6. Soft keys displayed on the screen allow the driver to change the scale (zoom level) of the map, pan the map from side-to-side or up and down, change the orientation of the map to North up, and display additional street names.

The driver is given two methods of obtaining emergency help. "Emergency" can be selected from the Main Menu. It is also one of the choices given in response to activating

Figure 5. The Services/Attractions Menu

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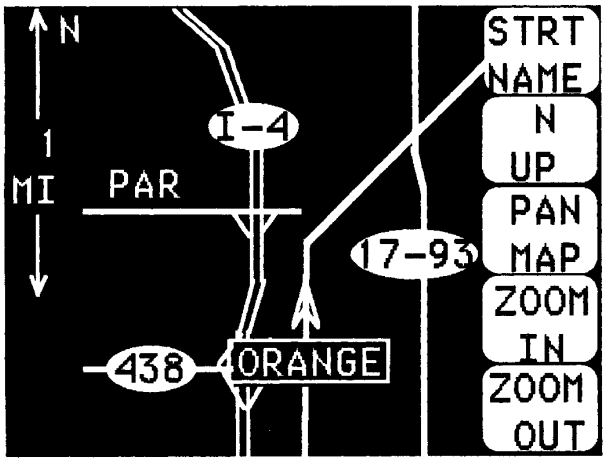

Figure 6. Map of Local Area Display

the Help soft key that is present on many of the pre-drive screens. The Emergency screen (Figure 7) gives a choice of Police/Fire/Medical help, Road Service help, or cancelling the request. If the police/fire/medical choice is selected, the cellular phone is automatically dialed and a screen with pertinent information is presented (Figure 8). A similar screen is presented when Road Service is selected, and AAA Road Service is dialed automatically.

A series of design studies using naive subjects drawn from the general population was performed to arrive at display screens that are as self-teaching as possible. The display

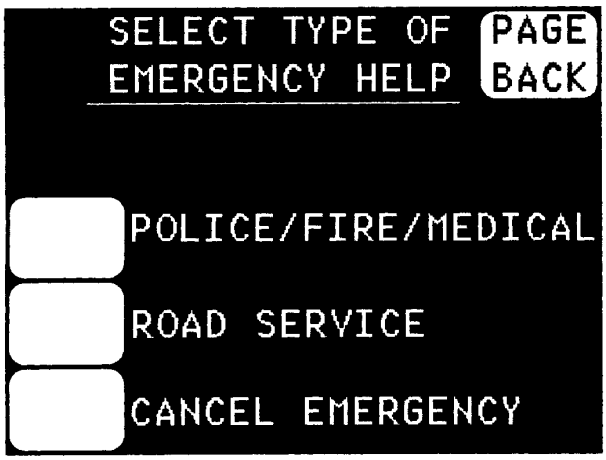

Figure 7. Emergency Help Screen

screen designs resulting from these comprehension tests are intended to facilitate user understanding of what to do and what will happen when soft keys are activated. To enhance driver understanding of how to operate TravTek, a Help key is provided on almost all of the pre-drive screens. In addition to using the Help key to request emergency help, the driver can also request screen instructions or connection to the Help Line at the TravTek Information and Services Center (the TISC) via the cellular

Figure 8. Police/Fire/Medical Screen

phone. The operator at the TISC has a system similar to the one in the car and can step through the same screens the driver sees in order to provide meaningful help to the driver over the phone. The TISC has been fully described by Taylor (3).

The screen instructions available through the Help key are amplified in the on-screen tutorial that can be accessed from the Main Menu. The tutorial is divided into lessons covering all major functions. The driver can proceed through the entire tutorial, or can view lessons selectively. The extensive help screens, tutorial instructions, and the TISC Help Line are intended to obviate the need for extensive training sessions and bulky manuals.

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DRIVE FUNCTIONS

The TravTek-provided information that is available while the car is in motion includes three types of map screens, as well as traffic information.

INFORMATION MAP - If the driver begins driving without inputting a destination, a map screen appears that is like the browse map screen, except that it has no soft keys superimposed on it. We have designated this map an Information Map. The location of the car is shown on the map (see Figure 9), along with the zoom level and the direction the car is heading. If the driver wants to change the orientation of the map to North up, pan the map, or see additional street names, the car must first be put in Park. However, the zoom level can be changed when the car is at zero speed, such as when it

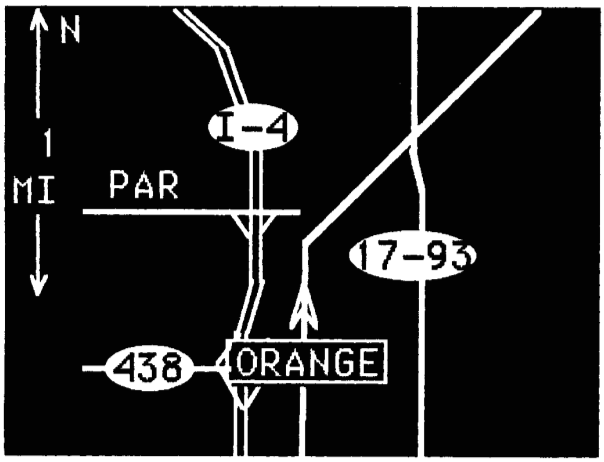

Figure 9. Information Map When In Motion

is stopped at a traffic light. When the car is at zero speed, the Zoom In and Zoom Out keys appear, as shown in Figure 10, and can be activated to change the zoom level. The keys disappear when the car is again put in motion. The position of the car is updated constantly because of the moving map background.

GUIDANCE MAPS - When a driver has input a destination, the drive map that is displayed is a much simplified turn map showing the next maneuver. These diagrammatic maneuver-by-maneuver guidance screens are designed to reduce demands on processing of visual

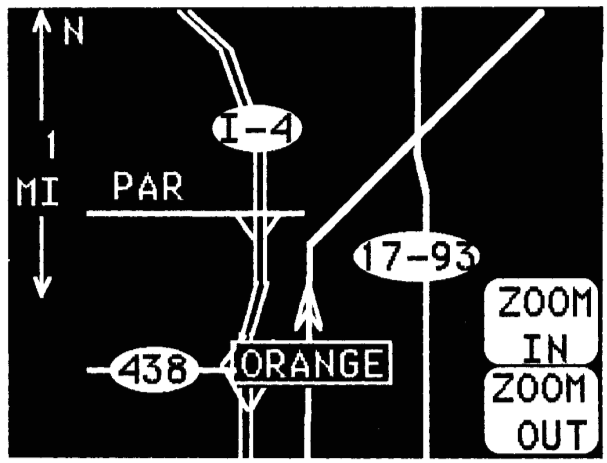

Figure 10. Information Map at Zero Speed

information. As shown in Figure 11, the map is a diagram of the intersection, with a turn arrow showing the direction of the turn as well as distance to the turn by stripes in the tail of the arrow. The name of the next street is displayed, along with a numeric representation of the distance to the turn. The name of the current street is also shown. At the top of the screen, the distance and approximate time to the destination are displayed. The distances on the display are updated as the car moves.

If the driver selects maneuver-by-maneuver voice guidance, which is done by activation of a steering wheel button, the voice is coordinated with the visual display. The voice

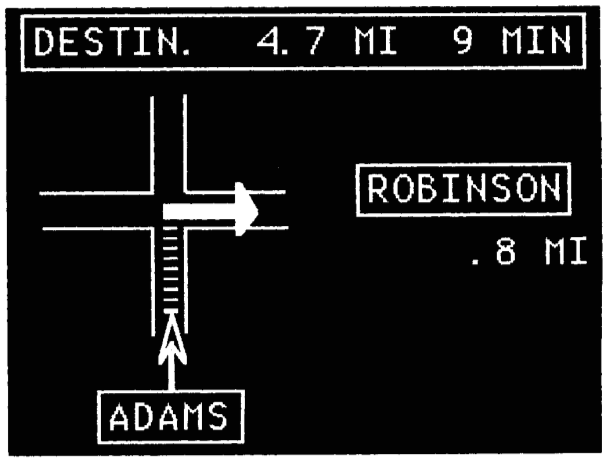

Figure 11. Guidance Map Display

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provides a preparatory message, e.g., "Prepare to turn right on Robinson Street", in sufficient time for the driver to change lanes if needed, and an at-turn message, "Turn right on Robinson Street". The driver can tell by a very swift glance at the display how far ahead the turn is. If the spoken street name was not understood, it can be viewed on the display, or the voice message can be repeated by activation of the "Repeat" button on the steering wheel. If the driver turns off the voice guidance, a tone is sounded to indicate the appearance of a new maneuver map, so that the driver knows when to glance at the screen.

Different map screen designs were evaluated in a laboratory study with naive subjects drawn from the general population. In a dual-task situation, the low-density Guidance Maps required less glance time and resulted in better performance than traditional map screens.

ROUTE MAP - Drivers may wish to see the total route displayed when they have input destinations, and can toggle to a Route Map by activating a steering wheel button. (This is an example of accommodating individual differences in the TravTek design.) The Route Map has the same appearance and functionality as the Information Map, with the addition of a destination symbol and a route line, as shown in Figure 12. If the car is put in Park, the zoom, pan, and other keys appear as they do on the Information Map. To return to the Guidance Map, the driver toggles the steering wheel switch again.

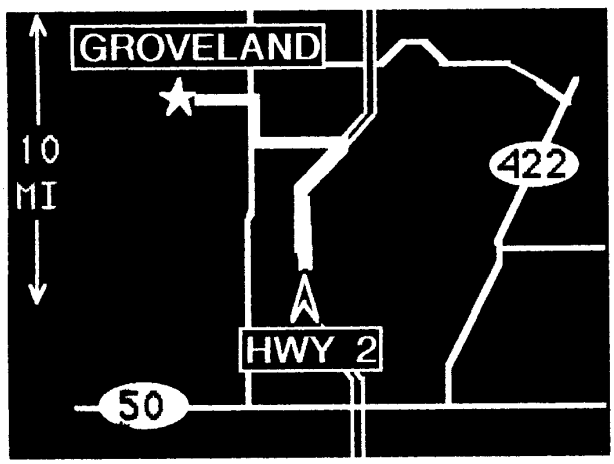

Figure 12. Route Map Display

TRAFFIC INFORMATION - Traffic information that is radioed to the computer in the car from the Traffic Management Center is used to provide both visual and auditory displays to the driver. The driver can turn the voice traffic reports on and off by operation of a steering wheel button. The traffic information is displayed visually on the different map screens. If a Guidance Map is displayed, a CAUTION AHEAD warning is superimposed on the screen when information is received about congestion or an incident ahead on the planned route, as shown in Figure 13. If the

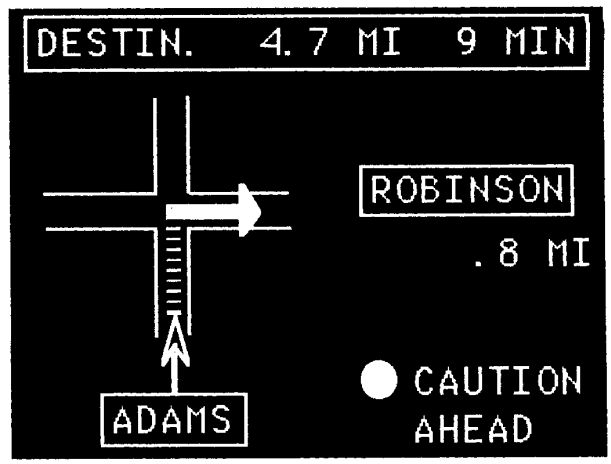

Figure 13. Guidance Map With Traffic Warning Superimposed

Information Map or Route Map is displayed, color-coded symbols are added to the map to show moderate congestion (hollow octagons), heavy congestion (filled octagons), road blocked (X's), or accidents/other incidents (large octagon with superimposed icon) (see Figure 14). The Traffic Management Center has been described by Rupert (4).

CONCLUSION

This paper has provided some of the highlights of the design effort to incorporate good human engineering into the TravTek driver interface. Additional information can be found in a recent paper presented at the Human Factors Society annual convention by Fleischman et al (5).

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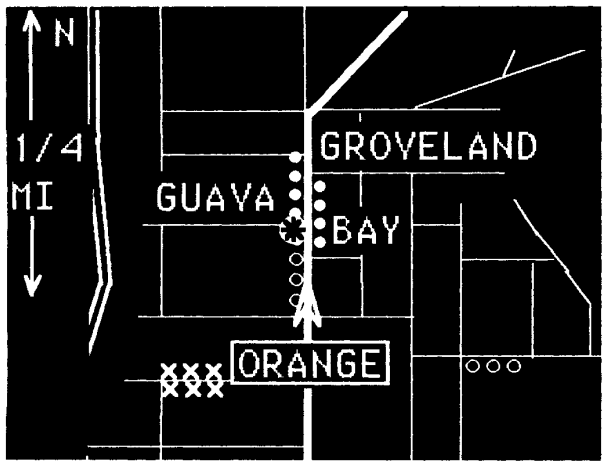

Figure 14. Traffic Information Overlaid on a Map

A considerable effort has been focused on human factors in TravTek. However, there remains a lot to be done, especially in the form of over-the-road studies. The year-long operational field test and evaluation will give us the opportunity to investigate the relationships between measures of attention, driving performance and safety. The TravTek evaluation and research effort is described by Fleischman (6) and Burgett (7). We look forward to learning more about the vital factors to be considered in developing Advanced Driver Information System driver interfaces.

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