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Prediction of Menu Selection Times Parked and While Driving Using the SAE J2365 Method

Christopher Nowakowski
Paul Green

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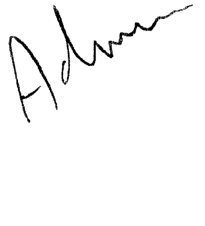

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16. Abstract

Recent concern has been expressed over the use of cell phones and navigation systems while driving. Several efforts, including SAE Recommended Practice J2364 ("the 15-second rule") and J2365 (the associated calculation procedure), have recently tried to provide guidelines for the design of in-vehicle devices. The purpose of this study was to examine a destination selection task in the model year 2000 Nissan Infiniti I30 navigation system (which was currently allowed while driving) in the context of SAE J2364 and J2365.

Eight licensed drivers between the ages of 20 and 30 (mean of 25 years old) selected destinations using the in-vehicle navigation system's address book and nearby points of interest features. The tasks were performed both while the vehicle was parked and while driving on a 2-lane expressway during low-volume traffic conditions at 70 mph.

The mean measured task time while the vehicle was parked was 13.20 seconds, requiring an average of 8.8 keystrokes to complete the task. The mean measured-task time while driving on the expressway was 15.85 seconds or approximately 1.2 times the measured task time while parked.

Subtracting system delays greater than 1.5 seconds, the mean keying time was 6.13 seconds when the vehicle was parked. Consequently, given that SAE J2364 specifies testing older drivers who typically take up to 1.8 time longer to complete in-vehicle tasks, a task of 11 keystrokes or less would pass the "15-second rule." SAE J2365 was also used to estimated the task times while the vehicle was parked, and it was found to slightly overestimate the task times by a mean of 0.68 seconds.

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UMTRI January, 2001
Christopher Nowakowski and Paul Green
University of Michigan
Ann Arbor, Michigan, USA

1 Issues

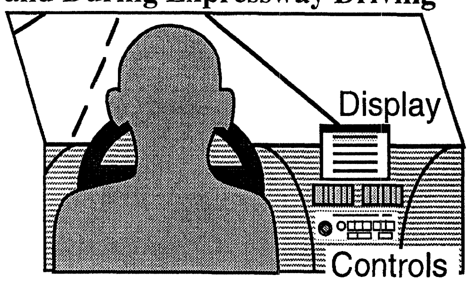
1. How does the menu-selection task time vary with the number of keystrokes?
2. How do the task times obtained for single task entry (while parked) compare to the task times obtained during dual task conditions (entry while driving)?
3. How do estimates from SAE J2365 compare with the task times obtained experimentally?
4. How could the operator elements in SAE J2365 be adjusted to obtain a better fit to the task times obtained experimentally?

2 Test Plan

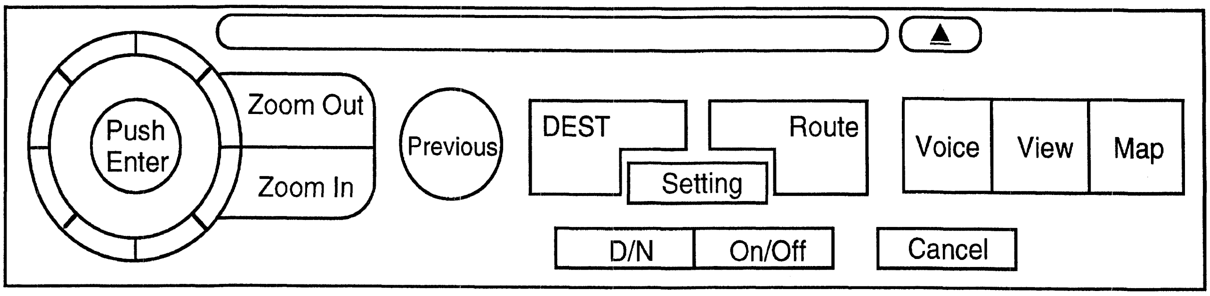
Test Participants (N=8)

Drivers Age 20-30	Nav. System Experience: Experienced	Nav. System Experience: Never Seen
Men	2	2
Women	2	2

Task Performed While Parked and During Expressway Driving

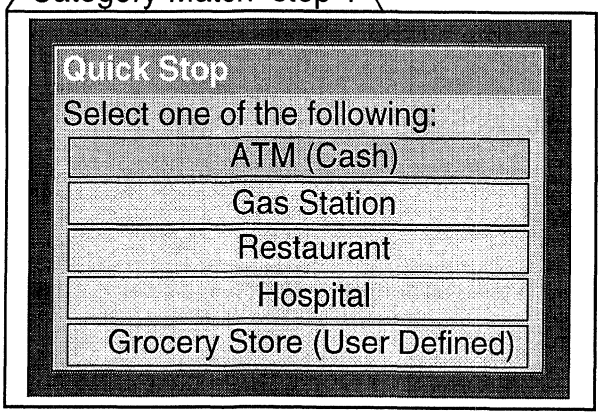


Control Layout (2000 Nissan Infiniti I30/Q45)

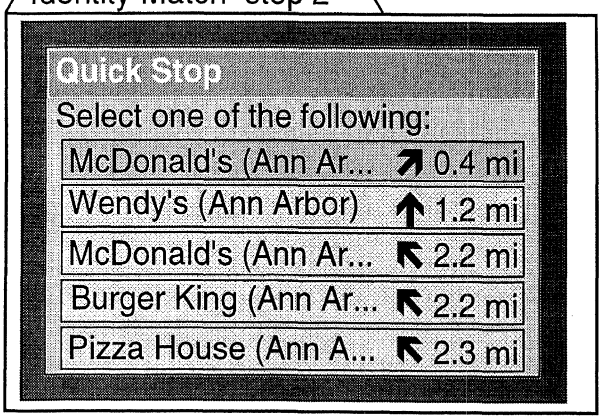


Destination Selection Task (Nearby Point of Interest)

Category Match–step 1



Identity Match–step 2

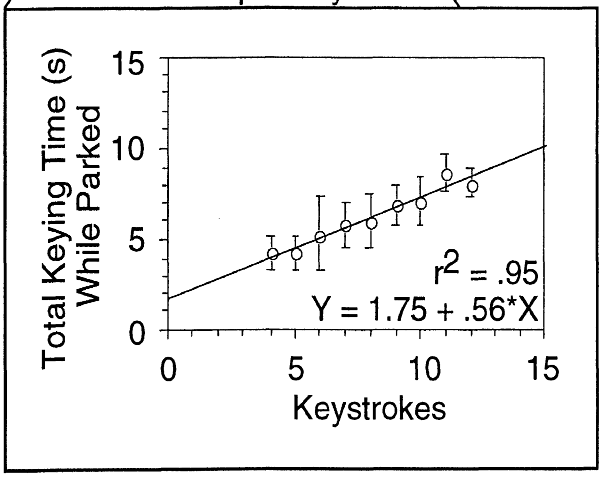


3 Results - Destination Selection

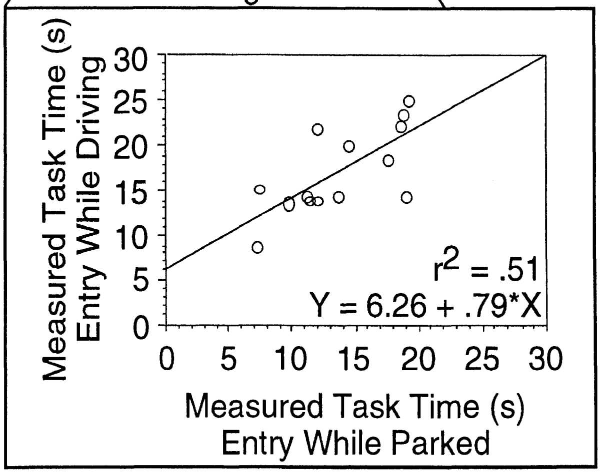
Task Time Summary

	Overall Number of Keystrokes	While Parked Measured Task Time (s)	While Parked System Delay (s)	While Parked Keying Time (s)	While Driving Measured Task Time (s)
Mean	8.8	13.20	7.07	6.13	15.85
Std. Dev.	2.4	4.55	3.18	1.87	5.79
Minimum	4.0	6.43	3.23	3.03	4.90
Maximum	13.0	22.97	13.97	9.97	30.67

Issue 1: Time per Keystroke

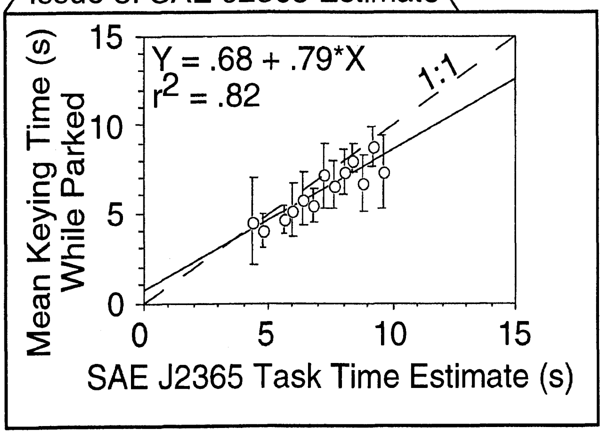


Issue 2: Driving vs. Parked

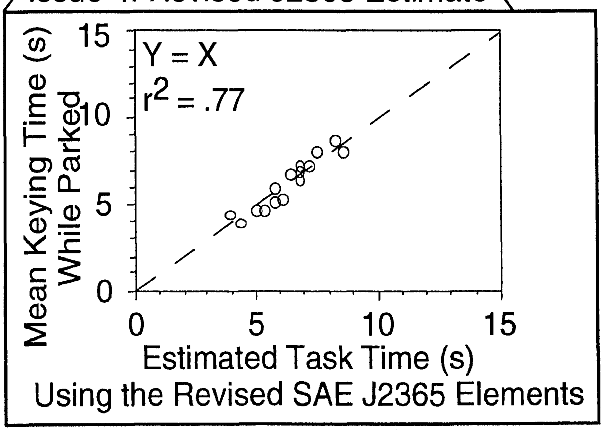


4 Results - Implications for SAE J2364 and J2365

Issue 3: SAE J2365 Estimate



Issue 4: Revised J2365 Estimate



Issue 4: SAE J2365 Operator Estimates

Operator Elements	SAE J2365 Estimate (s)	Revised Estimate (s)
Enter Keystrokes	1.20	1.06
1st Cursor Keystroke	0.80	0.72
Additional Cursor Keystrokes	0.40	0.36

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INTRODUCTION

Overview

Data from Japan indicate that using cell phones and navigation systems while driving can lead to an increased risk of crashes (Green, 2000), and because of task similarities, other telematics applications could have the same result. To minimize the crash risk, there have been several efforts to provide recommendations and guidelines to improve the driver interface design of navigation systems. (See Green, 1999a for a review.) These include the BSI guidelines (British Standards Institution, 1996); the JAMA guidelines (Japan Automobile Manufacturers Association, 2000); the EU guidleines (European Union, 1998); the HARDIE guidelines (Ross, Vaughn, Engert, Peters, Burnett, and May, 1995); and several guidelines prepared for the U.S. Department of Transportation (Green, Levison, Paelke, and Serafin, 1993, and Campbell, Carney, and Kantowitz, 1997).

Two recent efforts to provide design guidelines for in-vehicle navigation systems include: (1) the development of the In-Vehicle Information Systems DEMAnD Behavioral Model (Hankey, Dingus, Hanowski, Wierwille, and Andrews, 2000a,b) and (2) the development of a recommended practice by the Society of Automotive Engineers, SAE J2364 (Farber, Foley, and Scott, 2000; Green, 1999c,d; and the Society of Automotive Engineers, 2000).

The IVIS DEMAnD model is a resource based model of driving and secondary task performance. Using this model, key components of the task (such as the longest expected glance to the display, the total task time, and the expected number of glances required to complete the task) are recorded or estimated. Templates are provided for a limited number of predefined tasks that can be used to help estimate the key model parameters (such as the total task time). The model then uses these key parameters in conjunction with the visual, auditory, cognitive, and manual resources used by the in-vehicle task to estimate the amount of interference with driving caused by the task.

The central focus of the SAE effort has been to clearly define which functions should and should not be accessible to the driver when the vehicle is moving and, recently, this has led to a significant level of interest in the topic of driver distraction. SAE J2364 stipulates that "Any navigation function that is accessible by the driver while a vehicle is in motion shall have a static total task time of less than 15 seconds." (Society of Automotive Engineers, 2000). The timing starts when the driver moves his or her hand from the wheel to begin the task and ends when feedback from the last step of the task is received. The vehicle (or mockup) is assumed to be parked during the testing. The rule only applies to navigation systems with visual displays and manual controls. The 15-second rule represents a compromise given the various views of those voting for the recommended practice, the safety implications from recent research on the use of navigation and other systems, and the boundaries of what is considered acceptable for conventional in-vehicle controls and displays.

SAE J2364 includes a compliance procedure that involves testing a sample of drivers using a working device. Compliance with J2364 does not assure that a task is safe to do while driving, only that the most egregious tasks are not permitted. It is possible, that some tasks that should not be performed while driving could comply with SAE J2364. While the practice does not directly address all possible sources or mechanisms of distraction, it represents a reasonable, practical, first cut at reducing the likelihood of system induced crashes. As additional research is completed, this recommended practice is likely to be enhanced.

A key lesson from the literature on human computer interaction is the importance of early evaluation of usability (Gould and Lewis, 1985). Thus, to support J2364, a procedure was needed to estimate compliance early in design, during the conceptual stage. At this stage, changes in the user interface can be made very quickly at no cost. This need led to the development of SAE J2365 (Green, 1999a,b). SAE J2365 provides a hierarchical method for (1) describing user actions on a step-by-step basis, (2) using look-up tables of estimates for mental operations, visual search, and various keystrokes, and (3) adding the operators to estimate the total task time. The approach was based on the GOMS method (goals, operators, methods, and selection rules) commonly used for evaluating the user interfaces of computer systems (Card, Moran, and Newell, 1980, 1983) as well as for specific studies of automotive navigation systems (Steinfeld, Manes, Green, and Hunter, 1996; Manes and Green, 1997; Manes, Green, and Hunter, 1998; and Green, 1999d).

Selecting Tasks to Study

There has been considerable debate concerning SAE J2364 and J2365. To provide a scientific basis for further discussion, SAE J2365 predictions and static task times for tasks near the 15-second limit were desired. Therefore, in selecting tasks, the following items were considered:

1. Would access to the feature be desired while driving?
2. How often would the feature be used?
3. Was the feature already accessible while driving in current navigation systems?
4. Could the task be accomplished within the boundaries of the 15-second rule?

The task of setting a nearby point of interest (POI) was chosen because it met all of the criteria specified above. This particular entry task was also chosen because it was menu based, and menu tasks while driving have not been examined extensively. Given that many other current and future in-vehicle tasks involve the use of menus, examining this entry task should provide design information that might be generalized to other menu selection tasks. The literature on menus is substantial and best covered in *The Psychology of Menu Selection* (Norman, 1991). However, most of the menu selection work has focused only on the item selection time (assuming that all physical responses required for any particular item were equal such as when using a touch screen). The task being studied in the current experiment differs from the classic menu literature in that responses were made with cursor keys. Thus, selecting a given menu item required multiple keystrokes. Given this limitation, the results of the current experiment may not be comparable to the results of the traditional menu selection experiments.

In particular, one study on menu design described 2 types of menu selection tasks, category matches and identity matches, that occurred when using hierarchical menus (Miller, 1980, 1981). In the destination entry task, the driver might be asked to set the nearest McDonald's as the destination. The first part of this task would involve a category match such as selecting "restaurant" from a list of destination types. The second part of the task would involve an identity match that entails selecting the exact item ("McDonald's" in this case) from the list of destinations. Miller's work predicted that category matches should require more time to complete than identity matches.

At least one study has examined the application of SAE J2365 in the context of destination entry and menu item selection (Nowakowski, Utsui, and Green, 2000). In this driving simulator study, destinations were selected from lists using 2 types of input devices. The lists were organized such that there were 6 items per screen, with 2 additional buttons on the screen for forward and back. Each task required exactly 10 keystrokes, and the task was performed both while parked and while driving.

The results of Nowakowski, Utsui, and Green (2000) suggested that the operator estimates in SAE J2365 could vary by as much as 20 percent depending on the input device. For the particular interface and input devices studied, the total task time (while the vehicle was parked) ranged from an average of 17.5 to 21.7 seconds (for drivers under the age of 30). Additionally, the total task time increased by a factor of 1.27 when the task was performed while driving.

Issues

As noted earlier, given the history of discussions concerning the SAE recommended practices, the main purpose of this project was to gather additional data to validate SAE J2365. Specifically, the issues examined were as follows:

1. How do task times estimated using SAE J2365 compare with the task times obtained experimentally?
2. How does menu selection time vary with menu item position (or the number of keystrokes)?
3. How do the task times obtained for single task entry (while parked) correlate with the task times obtained during dual task conditions (entry while driving)?
4. Is this interface in compliance with SAE J2364 for nearby POI (point of interest) selection tasks?

TEST PLAN

Test Participants

Eight licensed drivers participated in this experiment (4 women and 4 men), each between 20 and 30 years of age (with a mean of 25). Funding constraints did not permit inclusion of an older driver sample as is typical practice at UMTRI for studies of this type. Participants were recruited from the UMTRI subject database, which was compiled from the respondents to past newspaper advertisements for previous experiments. All were paid $20 for their participation.

Four of the test participants reported prior experience with navigation systems. Three of the test participants had participated in previous experiments involving navigation system usability or destination entry on systems from different manufacturers.

Test Materials and Equipment

The test vehicle was a left-hand drive Nissan Infiniti I30 (model year 2000) with an automatic transmission. The in-vehicle navigation system was a manufacturer's option on this model. The database CD used during this experiment covered Michigan, Indiana, and part of Ohio, Illinois, and Wisconsin. As shown in Figure 1, the navigation system used a retractable 5 1/2-inch display shaded by a cover mounted on top of the center console. The controls for the navigation system were located in the middle of the center console (below the heating vents and above the radio controls).

Figure 1. Infiniti I30 center console with the optional navigation system.

Figure 2 depicts the layout of the navigation system's controls. The joystick on the left (labeled "Push Enter") controlled all of the cursor and enter movements on the screen.

The button labeled previous was used to back up one menu level, and the cancel button (in the lower right-hand corner) was used to leave the menu system at any point and return to the map view. The destination entry menus (Figures 3 and 4) were activated by pushing the DEST or the Route button. As each level of menu appeared, the cursor highlight defaulted to the top item in the menu.

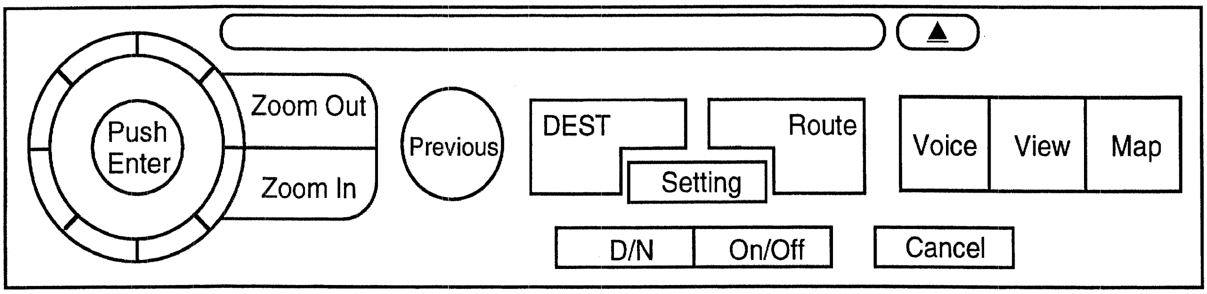

Figure 2. Diagram of the I30's navigation system control panel.

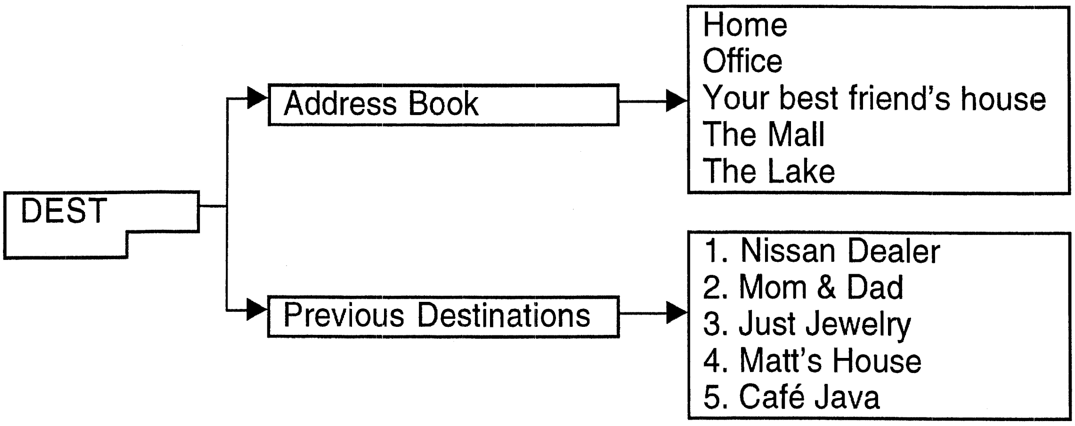

Figure 3. Destination menu tree.

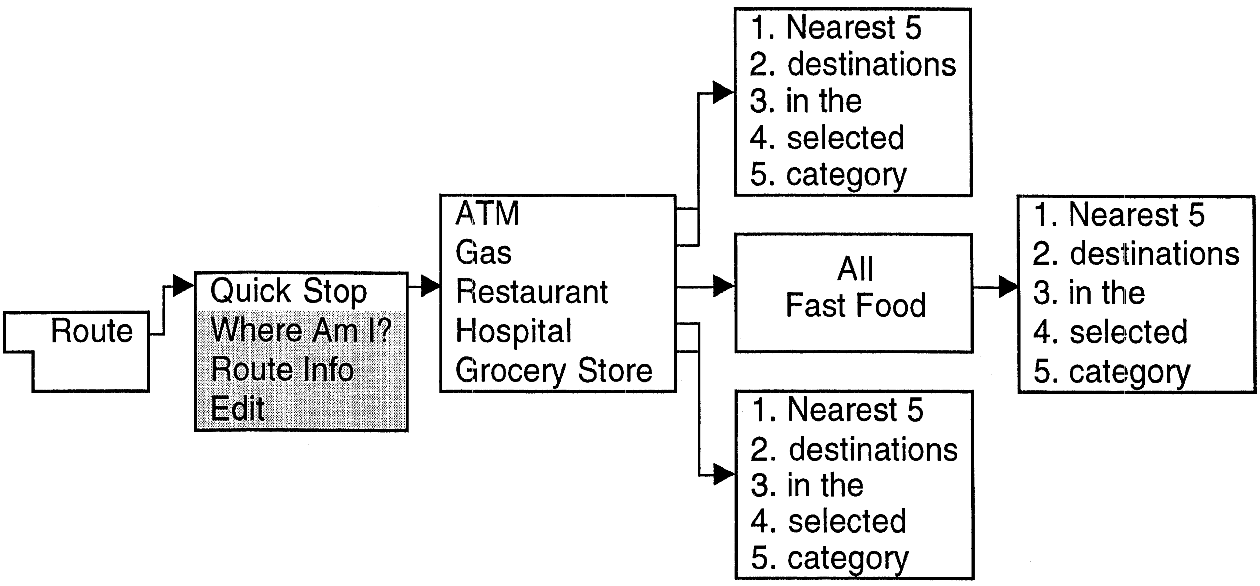

Figure 4. Route menu tree.

The address book and previous destinations list were preprogrammed before the start of the experiment. The Quick Stop feature calculated the 5 nearest destinations in the selected category based on the vehicle's current location. Given that this calculation was performed in real time, there was often a delay of several seconds between the category selection and the appearance of the completed destination list. Although the destination lists contained more than 5 destinations (accessible by scrolling), only the first 5 destinations were available for selection while the vehicle was in motion.

The navigation system provided a single tone as auditory feedback each time a control was activated. After a destination was selected, the system automatically calculated a route. During the experiment, the experimenter cancelled the route calculation by pressing the cancel button before the route calculation was completed. All other auditory guidance was disabled during the experiment.

Test Activities and Their Sequence

The experiment consisted of 3 parts in a fixed order as described in Table 1. The order was fixed for convenience. Each subject began by completing a consent form (Appendix A) and displaying a valid driver's license for the United States. Next, during the practice session, the experimenter gave the driver an overview of the system and then talked the driver through the first 5 practice trials. The target destination for each trial was read aloud by the experimenter who was sitting in the passenger seat. A list of the destinations available for each trial can be found in Appendix B.

Table 1. Overview of experimental sessions.

Part	Task	Vehicle Location	Trials
1	Practice	Parked	5
2	Destination Entry	Parked	16
3	Destination Entry	Expressway	24

The target destination name was read exactly as it appeared in the destination selection list. The name of the category containing the target destination was also provided in the context of the instructions. Three typical trials are listed below:

1. "Select Wendy's from the nearby fast food restaurants list."
2. "Select your best friend's house from the address book."
3. "Select the Nissan dealer from the previous destinations list."

During the third part of the experiment, the drivers drove an 8-mile stretch of the M-14 expressway north of Ann Arbor, Michigan (between Ford Road and Beck Road as shown in Appendix C). While driving at 70 mph, the experimenter read the target destinations at a rate of approximately 1.5 destinations per mile (about 1 every 45 seconds). A trial was not started until the driver was maintaining 70 mph with no potential interference from other nearby vehicles. While the driver was engaged in the task, the experimenter acted as a safety observer. The experimenter allowed the driver at least 5 to 10 seconds of rest between trials.

Data Reduction

Keystrokes and eye glances were recorded using a Panasonic (Model AG-5700) VHS recorder at 30 frames per second from a Hitachi VM-H38A camcorder split with a Panasonic GP-KS152 lipstick camera. (See Figure 5.) Though not apparent in this figure, a portion of the road scene was visible in the upper right hand corner of the recorded image. The recordings were then analyzed using a frame accurate VCR (Panasonic Model AG-DS550) and a 13-inch, high-quality, color monitor (Sony Trinitron) to determine the measured task times. The measured task time began when the first key was pressed and ended the moment that the last key required to enter the destination was pressed. Because the system provided a tone each time a key was pressed, there was no ambiguity regarding the start or end of a trial.

Figure 5. Split-screen image captured from the in-vehicle video recording system.

To simplify the analysis of trials where the vehicle was in motion, only the measured task time was analyzed. (The inter-keystroke intervals and other data may be obtained in future analyses and reported in a subsequent report.) For the trials with a parked vehicle, the duration of each step of the destination entry process (such as the time to select an item from a menu) and the system delays in excess 1.5 second (as specified in SAE J2364) were also noted to allow for the computation of the keying time. The keying time was defined as the time the driver actually spent engaged in the task, or the measured task time minus the system delays. (See Figure 6.) As mentioned above, a limited view of the traffic was also available in the upper right-hand corner of the recorded video, but there were no lane departures or other obvious driving errors to analyze.

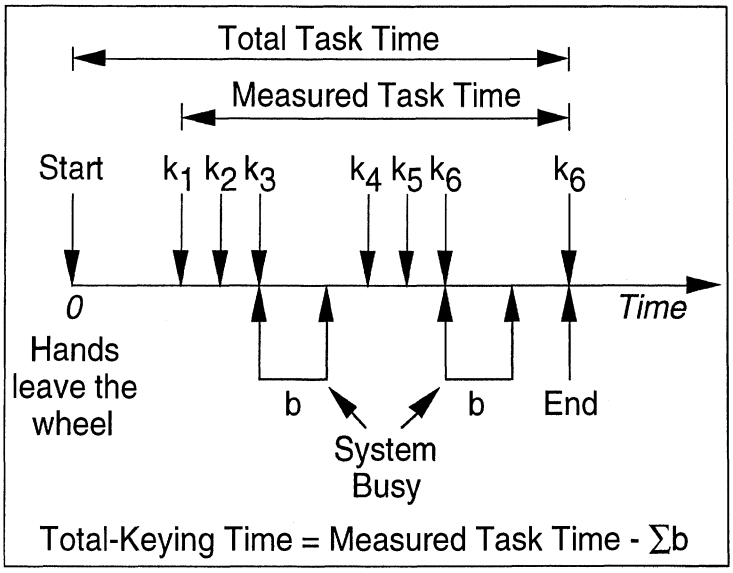

Figure 6. Definitions for total task, measured task, and keying time.

SAE J2365 Keying Time Estimates

Keying time estimates for each of the 16 trials performed in a parked vehicle were computed using SAE J2365. The element operators used were taken from SAE J2365 and the details of the calculations for these estimates are listed in Appendix D. The estimates for the interface used only the first cursor keystroke (0.8 seconds), additional cursor keystrokes (0.4 seconds), and enter keystrokes (1.2 seconds) as the elements for the task. No mental operations were used in the estimates for this task. Because the measured task time did not include the reach to the navigation system or the time to make the first keypress, these elements were not included in the total-task time estimates, which allowed for a direct comparison between the calculated estimates and the experimental findings. Had the reach to the navigation system been included, 0.45 seconds would have been added to each trial.

RESULTS

Destination Entry – Vehicle Parked

Overview

The experiment resulted in 128 trials (or destinations entered) while the vehicle was parked, but only 107 trials were analyzed as the remaining 21 trials contained errors (extra keystrokes). As shown in Table 2, the mean measured task time was 13.20 seconds ranging from a low of 6.43 to a high of 22.97 seconds. The mean for trials containing errors was 16.75 seconds or 27 percent higher, due to the extra keystrokes. These estimates include the system response time (delays), which averaged 7.07 seconds. According to SAE J2364, if system response times were greater than 1.5 seconds and feedback regarding the delay was provided, the system response time should not be included in the total task time. With the system delay removed, the mean keying time was 6.13 seconds ranging from a low of 3.03 to a high of 9.97 seconds. As shown in Figure 7, the difference in mean keying time between female (6.18 seconds) and male (6.08 seconds) test participants was negligible. Keep in mind that these times do not include the time to reach from the steering wheel to press the first button. Had the measurement followed the "15-second rule" (SAE J2364) precisely, the first reach would have added about 0.45 seconds to the measured task times.

Table 2. Task time summary for destination entry while parked.

	Measured Task Time (s)	System Delay (s)	Keying Time (s)	Keystrokes
Mean	13.20	7.07	6.13	8.8
Std. Dev.	4.55	3.18	1.87	2.4
Minimum	6.43	3.23	3.03	5.0
Maximum	22.97	13.97	9.97	13.0

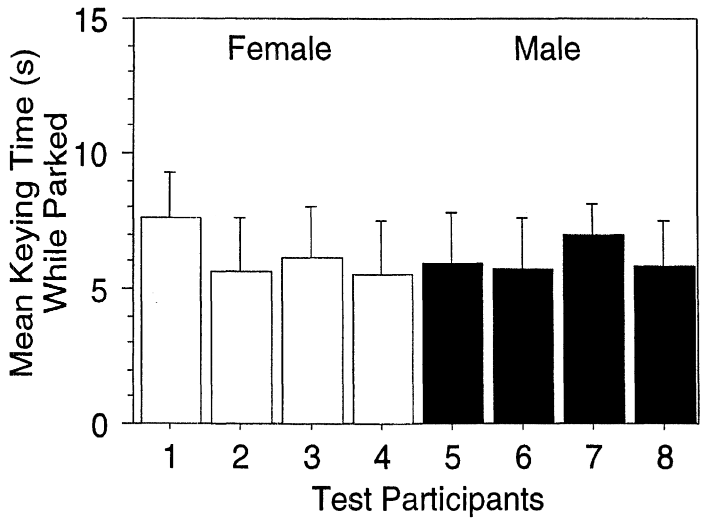

Figure 7. Mean keying time while parked by test participant. (Note: Error bars for all graphs denote 1 standard deviation.)

The system response time or delay (Figure 8) was largely due to the database search times, which were not consistent between trials or between test participants (within the same trial). Therefore, the delays could not be reliably predicted. The longest system delays (trials 1, 5, 9, 14, and 16) were found when selecting an item from the grocery store list or the fast food list.

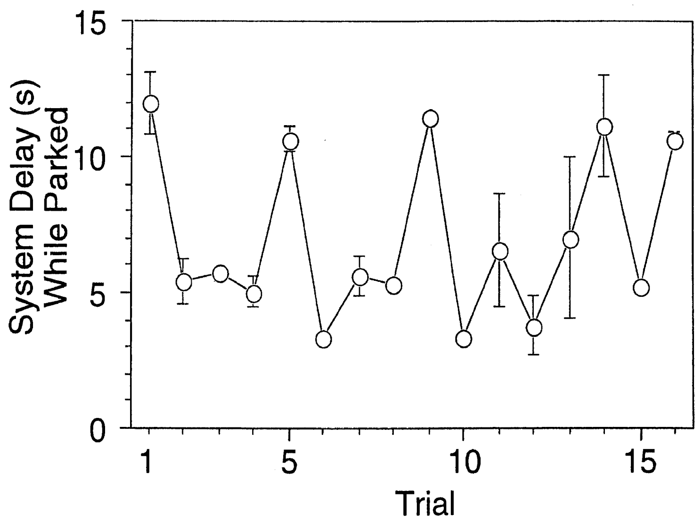

Figure 8. Mean system delay while parked by trial.

Total Task Time vs. Keystrokes

There was a linear relationship between the keying time and the number of keystrokes (ignoring the first keystroke since it was not timed) as shown in Figure 9. There was, however, a great deal of variability across trials and test participants in the keystroke estimate, which could be due to the fact that the duration of certain types of keystrokes can be double or triple that of others. For example, as suggested by SAE J2365, a second successive cursor keystroke should take 0.4 seconds, or half the time required for the first cursor keystroke (0.8 seconds). Thus, 2 trials with the same number of keystrokes could result in different estimates if one trial contained more repetitive keystrokes than the other.

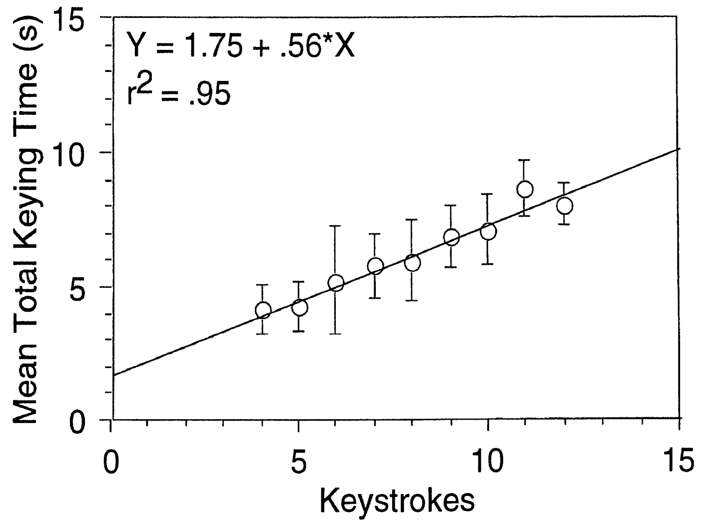

Figure 9. Mean keying time while parked as a function of keystrokes.

As noted in J2365, the times for older drivers are about 1.8 times that of younger drivers. Thus, the 15-second time limit of the older drivers should be completed in about 8.3 seconds by younger drivers. According to Figure 9, for a cursor-bound menu task, a task of 11 keystrokes or less could be completed within the "15-second rule." However, other navigation systems or navigation tasks may not be as structured or completed as swiftly.

Total Task Time vs. SAE J2365 Estimates

Comparing the SAE J2365 task time estimates to the actual mean keying times (Figure 10), a relatively good linear correlation ($r^2 = .815$) was found. In Figure 10, a perfect 1:1 correlation between the estimates and the actual times would follow a line with a slope of 1, but as depicted, the SAE J2365 method consistently overestimates the keying times by a mean of 0.68 seconds. However, given that the SAE J2365 method was created to predict task times for a variety of controls and interfaces, some differences are expected due to the nature of the task, interface, and controls.

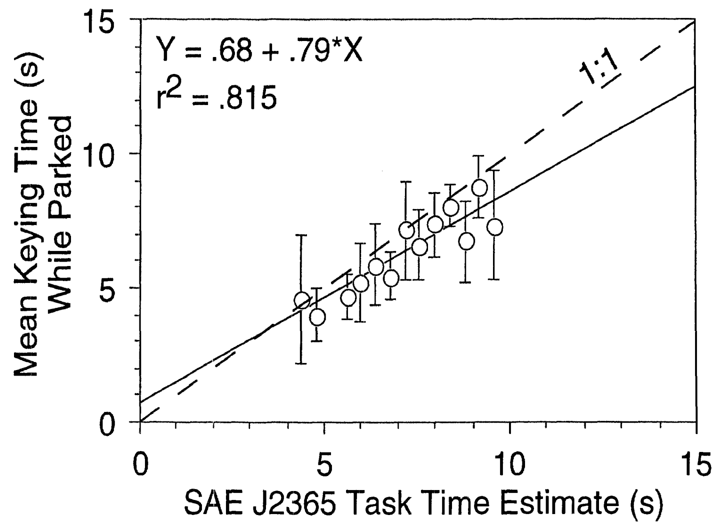

Figure 10. Comparison between the SAE J2365 estimates and the actual keying time.

Of particular interest are data points 11 and 13 in Figure 10, with predicted values of 8.8 and 9.6 seconds, respectively. These cases resulted in the worst errors, a keying time estimate of 9.6 seconds with an actual keying time of 7.3 seconds, a 31 percent margin of error. These 2 trials asked the drivers to set a fast food restaurant as the destination and resulted in much lower actual keying times (6.7 and 7.3 seconds, respectively) than predicted. Almost half of the overestimation for these 2 trials came from an intermediate step that asked the driver to select between all restaurants and fast food restaurants. Because this was a novel step in the entry sequence for this system and it was highly anticipated by the drivers (as they had seen the additional step during practice), the responses during this step were much faster. The SAE J2365 estimate predicted 0.8 seconds for a cursor keystroke and 1.2 seconds for an enter keystroke for a subtask time of 2.0 seconds, yet the mean time to complete both keystrokes during this step was less than 1.3 seconds.

SAE J2365 Operator Estimates

Although the actual keystroke times have yet to be obtained from the videotapes of this study, estimates for the SAE J2365 operators were obtained using multiple linear regression techniques. Three elements first cursor keystrokes (C_1), additional cursor keystrokes (C_2), and enter keystrokes (E), were used to estimate the total task time. For each trial, an equation could be written of the form:

$$X^*C_1 + Y^*C_2 + Z^*E = \text{measured task time}$$

where,
X, Y, Z are the number of C_1, C_2, and E keystrokes, respectively, for the trial.

However, in the above equation, the variables' first cursor keystroke and additional cursor keystrokes are not independent, since an additional cursor keystroke cannot occur independently of a first cursor keystroke. Rewriting the equation to account for this interdependency provides the following (assuming that first cursor keystrokes will be twice the value of additional cursor keystrokes based upon the previous values given in SAE J2365):

$$X^*2C_2 + Y^*C_2 + Z^*E = \text{measured task time}$$

The resulting regression for the task while parked was significant, $F(2,13) = 67.42$, $p < .0001$. The intercept was not significant and thus removed from the model when estimating the keystroke operators. Enter keystrokes were estimated at 1.06 seconds ($p < .0001$). First cursor keystrokes were estimated at 0.72 seconds, and additional cursor keystrokes were estimated at 0.36 seconds ($p < .0001$). Using these values for the operator elements, the fitted model resulted in an r^2 of 0.77. (See Figure 11).

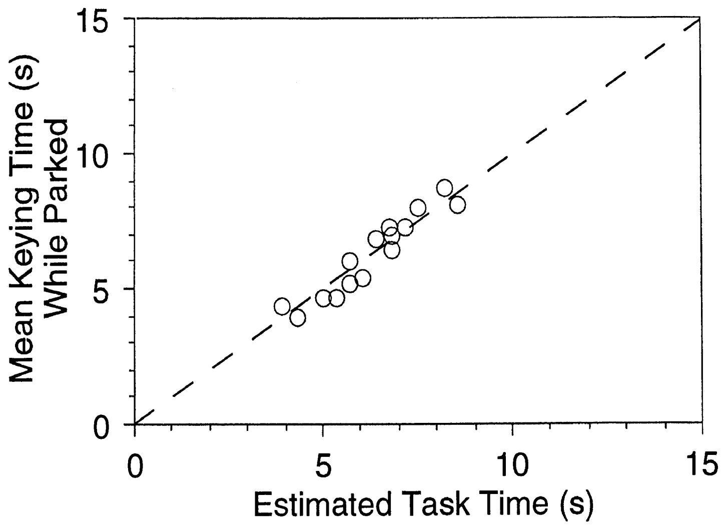

Figure 11. Comparison between the SAE J2365 estimates using the revised operator times from the regression and the actual keying time.

Menu Item Selection

The menu-item selection times for destination entry while parked were recorded during the video analysis. Two types of menu selections (as defined by Miller, 1980 and 1981) occurred during each trial. First, the driver was required to select the correct menu category for the target destination (referred to as a category match). Second, the driver was required to select the target item from the list of destinations (referred to as an identity match).

Accordingly, a repeated measures ANOVA was performed with menu selection type and item position as the within-subject measures. There was a marginally significant effect for the menu selection type, $F(1,7) = 4.97$, $p < 0.06$, indicating that the category match was performed slightly faster than the identity match (Figure 12). The item position, $F(3,21) = 42.48$, $p < 0.001$, and the item-position-by-menu-selection-type interaction, $F(3,21) = 4.05$, $p < 0.02$, were also significant.

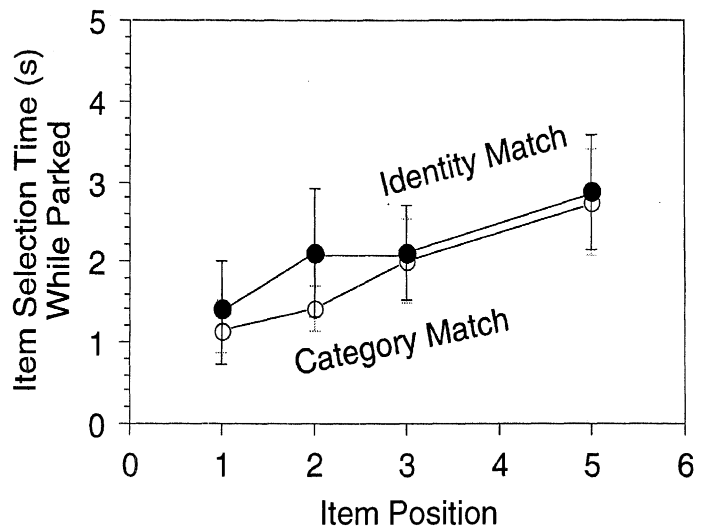

Figure 12. Menu-item selection time as a function of the item position.

Given that the number of keystrokes required to select an item was directly proportional to the item position, these results were not surprising. However, the interaction between item position and menu selection type which was seen only for selecting the second item during an identity match currently defies explanation. According to the SAE J2365 predictions (Figure 13), there should an increase and a departure from linearity for item 2; however, the time to select each additional item should then continue to increase linearly. (The increase corresponded to the fact that the additional cursor keystrokes to select item 3 or above required 0.4 seconds each while the first cursor keystrokes to reach item 2 required 0.8 seconds.)

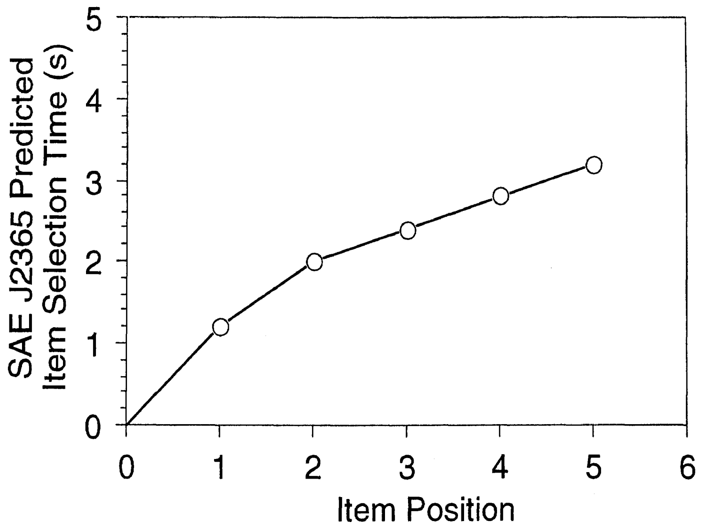

Figure 13. Item selection time based on SAE J2365 keystroke predictions.

Destination Entry - While Driving

Overview

The experiment resulted in 192 trials (or destinations entered) while drivers were travelling on the expressway, but only 174 trials were analyzed as the remaining 18 trials contained errors. As shown in Table 3, the mean measured task time was 15.85 seconds ranging from a low of 4.90 to a high of 30.67 seconds. The mean measured task time for trials with errors was slightly higher, 17.67 seconds, due to the extra keystrokes caused by the error. The mean measured task time included the system response times, and estimates for these response times could not be obtained. As shown in Figure 14, the difference in mean measured task time between female (15.50 seconds) and male (16.18 seconds) test participants was negligible.

Table 3. Task time summary for destination entry while driving.

	Measured Task Time (s)	Keystrokes
Mean	15.85	8.8
Std. Dev.	5.79	2.4
Minimum	4.90	4.0
Maximum	30.67	13.0

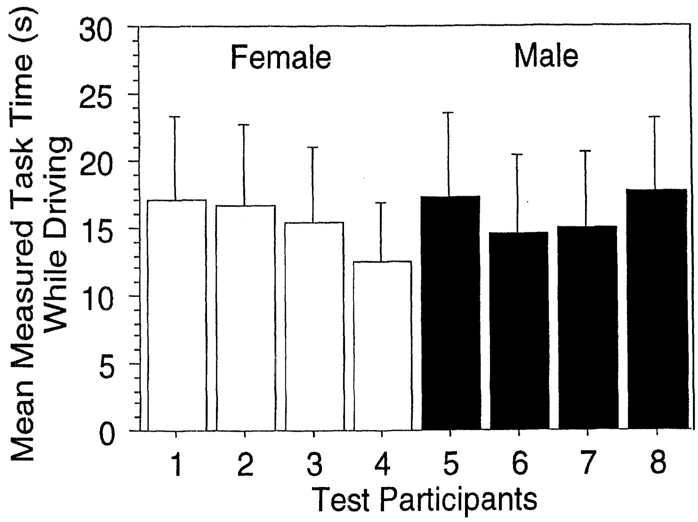

Figure 14. Mean total task time while driving by test participant.

Total Task Time vs. Keystrokes

There was a linear relationship between the measured task time (including the system delays) and the number of keystrokes (ignoring the first keystroke since it was not timed) as shown in Figure 15. The relationship between keystrokes and measured task time was not as strong for the dual task (entry while driving) condition (r^2 = 0.863) as it was for the single task (entry while parked) condition (r^2 = 0.95). As discussed previously, some of the additional variability may stem from the system delay which could not be estimated for the dual task condition but which varied greatly during the single task condition on both a trial-by-trial and subject-by-subject basis. Additionally, the task required multiple glances, so the measured task time was affected by the frequency of glances back to the road which may have been related to the strategies chosen by the driver or the moment-to-moment workload of the road and traffic conditions.

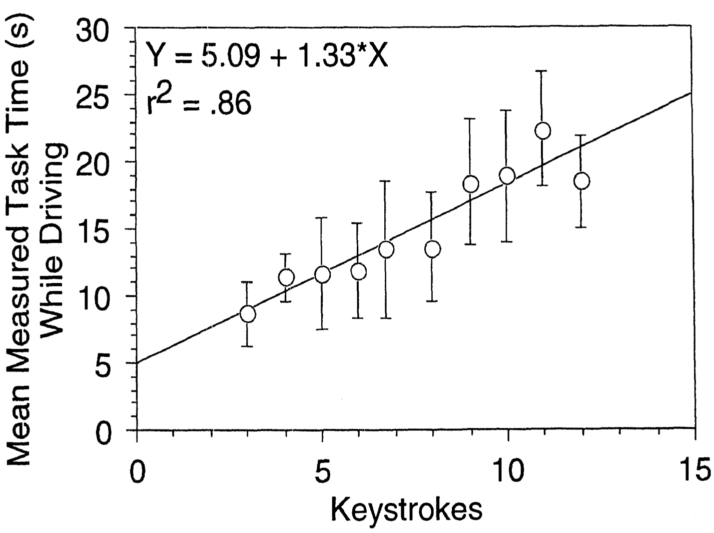

Figure 15. Mean measured task time while driving as a function of keystrokes.

Entry While Parked vs. Entry While Driving

Fourteen similar trials were performed in both the single and dual task portions of the experiment. Although the target destination was different between the single and dual task conditions, the item location and total number of keystrokes remained constant, allowing for a comparison of the measured task times (including system delays and averaged across subjects) between these conditions. As shown in Figure 16, the single task time was a only a modest predictor of the dual task time ($r^2 = 0.51$), keeping in mind that the study only examined 8 subjects. Adjusting the model to remove the Y-intercept, the measured task time while driving was approximately 1.2 times the measured task time while parked.

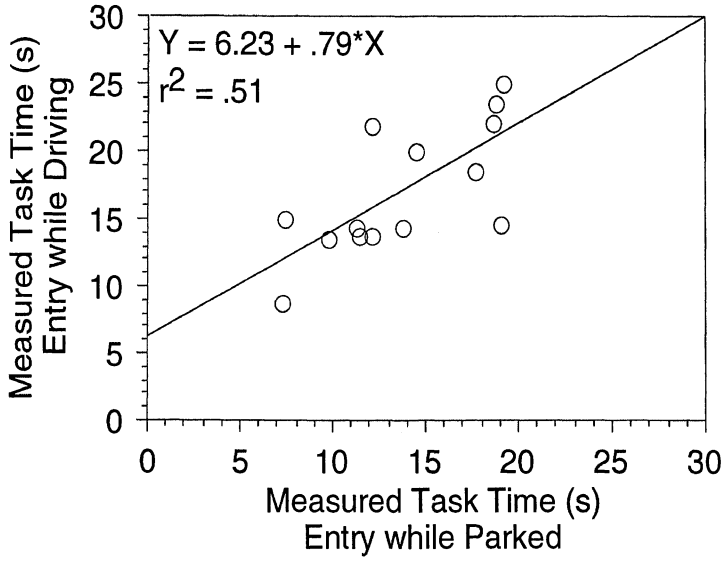

Figure 16. Predicting entry time while driving from entry time while parked.

CONCLUSIONS

1. How do task times estimated using SAE J2365 compare with the task times obtained experimentally?

The SAE J2365 calculation method was developed to assist in predicting the total task time for navigation system tasks performed while the vehicle was stationary. The experiment measured the task times of 16 navigation-system entry tasks performed while the vehicle was stationary by 8 drivers between the ages of 20 and 30. The mean measured task time (including system) for the entry tasks was 13.2 seconds, ranging from 6.43 to 22.97 seconds. The SAE method does not, however, include system delays greater than 1.5 seconds. Removing these delays from the measured task times, the mean keying time was 6.13 seconds, ranging from 3.03 seconds to 9.97 seconds. The estimates based on SAE J2365 for those same tasks ranged from 4.4 to 9.6 seconds. Averaging over the number of drivers, there was a good correlation (r^2 = .815) between the keying time and the estimated task time. Overall, the estimates were slightly lower than the measured task times by a mean of 0.68 seconds, with the largest differences ranging up to 1.5 seconds.

Although the actual keystroke times could not be measured, estimates were obtained for the first cursor keystroke, additional cursor keystrokes, and enter keystrokes using multiple linear regression as shown in Table 4. Overall, the revised estimates were 10 to 15 percent lower than the estimates from SAE J2365. These differences may reflect such factors as amount of practice or task difficulty, or factors such as the control design (button size, shape, and location). As an example, in this study, only 5 destination categories appeared in the same order for each trial. This made them easy to memorize, which could possibly account for some of the decrease in the keystroke times.

Table 4. Revised estimates for the SAE J2365 operators based on regression.

Keystroke Type	SAE J2365 Estimate (s)	Revised Estimates (s)
1st Cursor	0.80	0.72
Additional Cursors	0.40	0.36
Enter	1.20	1.06

2. How does menu selection time vary with menu item position (or the number of keystrokes)?

Two types of menu-item selection tasks have been identified in the literature: category matches and identity matches. The category match (matching the destination to the facility type, e.g., matching McDonald's to the fast food restaurants category) has been shown to require more time than the identity match (matching the target destination to the exact item on the screen). The results of this experiment showed no significant difference between the two types of menu-item selection tasks for this system.

Although this result appears contrary to the literature, several attributes of the experiment could explain the lack of a difference between the two types of matches. First, only 5 destination categories appeared in the same order for each trial. A classic menu study would randomize the order of these categories to prevent memorization of the menu order which would reduce the menu-item selection time. Second, when a target destination that might fall into multiple categories was given, the category name was also mentioned. This protocol would change many of the trials in the category match to identity matches.

Because the number of keystrokes required to select a menu item was directly proportional to the desired item's position, the time required to select a particular menu item was linear with a Y-intercept of .95 seconds and a slope of .38 seconds per keystroke.

3. How do the task times obtained for a single task entry (while parked) correlate with the task times obtained during dual task conditions (entry while driving)?

The experiment measured the task times of 24 navigation-system entry tasks performed by eight drivers between the ages of 20 and 30 while the vehicle was travelling on an expressway. The mean measured task time (including all system delays) for the entry tasks was 15.85 seconds, ranging from 4.90 to 30.67 seconds. Of these 24 trials, 14 were comparable to the trials performed while the vehicle was parked. Comparing the two conditions, the measured task times while driving were approximately 1.2 times the measured task times while parked for the driving workload explored (daytime, expressway, 70 mph, very light traffic, smooth road surface). As shown in Table 5, the results of this study compared reasonably well to the results of other studies.

Table 5. Relationship between dynamic and static task times.

Study	Task	Subjects, Ages	Roads	Task Time Ratio Dynamic/Static
Paelke and Green (1993)	Nav System	16, 18-70	Low Fidelity Simulator	1.1
Tijerina (1999)	Nav System Cell Phone Radio Controls	10, 55-65	Test Track	1.26
Tsimhomi, Yoo, and Green (1999)	Map Reading	16, 18-70	Simulator	1.55
Foley et al. (2000)	Nav System Cell Phone CD Changer Traffic Messages	40, 45-65	Simulator and Expressway	1.7
Nowakowski, Utsui, and Green (2000)	Nav System Menu Selection	16 18-65	Simulator	1.27

4. Is this interface in compliance with SAE J2364 for nearby POI (point of interest) selection tasks?

The "15-second rule" as specified in SAE J2364 calls for testing any feature that is to be accessible while driving to ensure that the task can be completed by older drivers in under 15 seconds while the vehicle is parked. The method used in this study only tested younger drivers with the device; however, past studies have shown that the response times for older drivers are on average 1.8 times those of younger drivers. Given this relationship, it could be extrapolated that any task completed by younger drivers in under 8.3 seconds would pass the "15-second rule" if the tests were rerun using older drivers. Since the mean keying time for this group of tasks was 6.13 seconds (with a mean of 8.8 keystrokes), it could be extrapolated that the point of interest selection task would be in compliance with SAE J2364 for the tested navigation system. Furthermore, based on a linear regression between the number of keystrokes and the mean keying time, a similar task using the tested interface would likely comply with SAE J2364 as long as it required 11 keystrokes or less to complete.

REFERENCES

British Standards Institution (1996). *Guide to In-Vehicle Information Systems* (Draft Document DD235:1996). London, U.K.: British Standards Institution.

Campbell, J.L., Carney, C., and Kantowitz, B.H. (1997). *Draft Human Factors Design Guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO).* Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.

Card, S.K., Moran, T.P., and Newell, A. (1980). The Keystroke-Level Model for User Performance Time with Interactive Systems. *Communications of the ACM*, July, *23*(7), 396-410.

Card, S.K., Moran, T.P., and Newell, A. (1983). *The Psychology of Human-Computer Interaction.* Hillsdale, NJ: Lawrence Erlbaum Associates.

European Commission (1998). *European Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems ("final version").* Brussels, Belgium: European Commission, Telematics Applications for Transport and the Environment, Task Force HMI (available from the International Standards Organization as document ISO/TC 22/SC 13/WG 8/N 181).

Farber, E., Foley, J. and Scott, S. (2000). *Visual Attention Design Limits for ITS In-Vehicle Systems: The Society of Automotive Engineers Standard for Limiting Visual Distraction while Driving.* Transportation Research Board 79th Annual Meeting.

Foley, J., Greenberg, J., Farber, G., Blanco, M., Curry, R., and Serafin, C. (2000). *Visual Demand While Driving.* Presentation to the SAE Safety and Human Factors Committee on March 24. Warrendale, PA: Society of Automotive Engineers.

Gould, J.D. and Lewis, C. (1985). Designing for Usability: Key Principles and What Designers Think. *Communications of the ACM*, March, *28*(3), 300-311.

Green, P. (1999a). Estimating Compliance with the 15-Second Rule for Driver-Interface Usability and Safety. *Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting* [CD-ROM]. Santa Monica, CA: Human Factors and Ergonomics Society.

Green, P. (1999b). *Navigation Systems Data Entry: Estimation of Task Times* (Technical Report UMTRI-99-17). Ann Arbor, MI: University of Michigan Transportation Research Institute.

Green, P. (1999c). The 15-Second Rule for Driver Information Systems [CD-ROM]. *ITS America Ninth Annual Meeting Conference Proceedings.* Washington, D.C.: ITS America.

Green, P. (1999d). *Visual and Task Demands of Driver Information Systems* (Technical Report UMTRI-98-16). Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Green, P. (2000). Crashes Induced by Driver Information Systems and What Can Be Done to Reduce Them (SAE paper 2000-01-C008), *Convergence 2000 Conference Proceedings*, (SAE publication P-360), Warrendale, PA: Society of Automotive Engineers, 26-36.

Green, P., Levison, W., Paelke, G., and Serafin, C. (1993). *Preliminary Human Factors Guidelines for Driver Information Systems* (Technical Report UMTRI-93-21). Ann Arbor, MI: The University of Michigan Transportation Research Institute (also published as FHWA-RD-94-087, McLean, VA: U.S. Department of Transportation, Federal Highway Administration, December, 1995).

Hankey, J.M., Dingus, T.A., Hanowski, R.J., Wierwille, W.W., and Andrews, C. (2000a). *In-Vehicle Information Systems Behavioral Model and Design Support: Final Report* (FHWA-RD-00-135). McLean, VA: Federal Highway Administration, U.S. Department of Transportation.

Hankey, J.M., Dingus, T.A., Hanowski, R.J., Wierwille, W.W., and Andrews, C. (2000b). *In-Vehicle Information Systems Behavioral Model and Design Support: IVIS DEMAnD Prototype Software User's Manual* (FHWA-RD-00-136). McLean, VA: Federal Highway Administration, U.S. Department of Transportation.

Japan Automobile Manufacturers Association (2000). *Guideline for In-vehicle Display Systems - Version 2.1* (February 22). Japan.

Manes, D. and Green, P. (1997). *Evaluation of a Driver Interfaces: Effects of Control Type (Knob Versus Buttons) and Menu Structure (Depth Versus Breadth)* (Technical Report UMTRI-97-42). Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Manes, D., Green, P., and Hunter, D. (1998). *Prediction of Destination Entry and Retrieval Times Using Keystroke-Level Models* (Technical Report UMTRI-96-37, also released as EECS-ITS LAB FT97-077). Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Miller, D.P. (1980). *Factors Affecting Item Acquisition Performance in Hierarchical Systems: Depth vs. Breadth* (Ph.D. dissertation). Columbus, OH: Ohio State University.

Miller, D.P. (1981). The Depth/Breadth Tradeoff in Hierarchical Computer Menus. *Proceedings of the Human Factors Society 25th Annual Meeting.* Santa Monica, CA: Human Factors and Ergonomics Society, 296-300.

Norman, K.L. (1991). *The Psychology of Menu Selection.* Norwood, NJ: Ablex.

Nowakowski, C., Utsui, Y., and Green, P. (2000). *Navigation System Evaluation: The Effects of Driver Workload and Input Devices on Destination Entry Time and Driving Performance and Their Implications to the SAE Recommended Practice* (Technical Report UMTRI-2000-20). Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Olson, J.R. and Nilsen, E. (1987-1988). Analysis of the Cognition Involved in Spreadsheet Software Interaction. *Human-Computer Interaction*, *3*, 309-349.

Paelke, G. and Green, P. (1993). *Entry of Destinations into Route Guidance Systems: A Human Factors Evaluation* (Technical Report UMTRI-93-45), Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Ross, T., Vaughn, G., Engert, A., Peters, H., Burnett, G., and May, A. (1995). *Human Factors Design Guidelines for Information Presentation by Route Guidance and Navigation Systems* (Deliverable 19, Workpackage L2). Luxembourg: European Commission Host Organization.

Society of Automotive Engineers (2000). *SAE draft Recommended Practice J2364 - Navigation and Route Guidance Function Accessibility while Driving* (Revision of January 20). Warrendale, PA: Society of Automotive Engineers.

Steinfeld, A., Manes, D., Green, P., and Hunter, D. (1996). *Destination Entry and Retrieval with the Ali-Scout Navigation System* (Technical Report UMTRI-96-30, also released as EECS-ITS LAB FT97-077). Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Tijerina, L. (1999). *A Test Track Evaluation of the 15-Second Rule*, Presentation to the SAE Safety and Human Factors Committee on February 26. Warrendale, PA: Society of Automotive Engineers.

Tsimhoni, O., Yoo, H., and Green, P. (1999). *Effects of Visual Demand and In-Vehicle Task Complexity on Driving and Task Performance as Assessed by Visual Occlusion* (Technical Report UMTRI-99-37), Ann Arbor, MI: The University of Michigan Transportation Research Institute.

APPENDIX A – Participant Consent Form

PARTICIPANT CONSENT FORM
Infiniti Navigation System Destination Entry Consent Form

Most major automakers have been developing navigation systems to aid drivers in reaching their destinations. In the past few years, several manufacturers have offered navigation systems as options on new vehicles. Though the potential benefits of these systems are great, there are still unresolved safety concerns over which features should be accessible while driving.

In the experiment today, you will spend about 45 minutes using the navigation system currently offered in the 2000 Nissan Infiniti. Detailed instructions will be provided on how to use the system before the experiment begins. During the first part of the experiment, you will enter destinations from various lists such as the address book or the nearby restaurant list while parked at UMTRI. Most of these tasks take less than 30 seconds each.

The second part of the experiment will involve entering similar destinations while driving on M-14 between Ford Road and Beck Road (just north of Ann Arbor). While performing the destination entry tasks, your first priority is to drive safely. The second priority is to complete the task both accurately and quickly.

Several cameras will be recording you as you perform the tasks. If you feel unsafe at any time, the trial or experiment can be stopped, and you will be paid regardless of whether you complete the experiment. For your time you will be paid $20.

If you have any questions, please do not hesitate to ask the experimenter at any time.

Thank you for your participation.

It is OK to show segments of my test session in presentations to UMTRI visitors, UMTRI papers and reports, and conferences and meetings. (This is not required for participation in the study but is useful to have. Your name will not be mentioned.)

*I agree*_______________ *I disagree*_____________

I have reviewed and understand the information presented above. My participation in this study is entirely voluntary.

______________________	______________________
Subject Name (PRINTED)	Date
______________________	______________________
Subject Signature	Witness (experimenter)

Investigators: Christopher Nowakowski, 763-2485
Paul Green, 763-3795

APPENDIX B – List of Test Trials

Part 1 – Practice Trials While Parked

Trial	List	Menu Position	List Item	Item Position	Total Keystrokes
1	Grocery Store	5	Rite Aid	2	10
2	Address Book	1	The Mall	4	7
3	ATM	1	Society Bank	5	9
4	Fast Food	3	McDonald's	1	9
5	Previous Dest.	2	Just Jewelry	3	7

Part 2 – Test Trials While Parked

Trial	List	Menu Position	List Item	Item Position	Total Keystrokes
1	Grocery Store	5	Dong Yu's China Market	3	11
2	Gas Station	2	Sunoco	3	8
3	Restaurant	3	Y&S Sandwich Shop	5	12
4	ATM	1	National City	2	6
5	Grocery Store	5	Busch's ValuLand	4	12
6	Previous Dest.	2	Café Java	5	9
7	Gas Station	2	Marathon	5	10
8	ATM	1	Society Bank	4	8
9	Fast Food	3	Wendy's	2	10
10	Address Book	1	Your best friend's house	3	6
11	Gas Station	2	Amoco	1	6
12	Previous Dest.	2	Nissan Dealer	1	5
13	Restaurant	3	Cottage Inn Pizza	1	8
14	Fast Food	3	Burger King	4	12
15	ATM	1	Comerica Bank	3	7
16	Grocery Store	5	Rite Aid	2	10

Part 3 – Test Trials While Driving East on M-14

Trial	List	Menu Position	List Item	Item Position	Total Keystrokes
1	Restaurant	3	Papa Romanos	5	12
2	Fast Food	3	Wendy's	2	10
3	Gas Station	2	Amoco	1	6
4	Address Book	1	The Lake	5	8
5	Gas Station	2	Boggs Gas	3	8
6	Grocery Store	5	Busch's ValuLand	5	13
7	Restaurant	3	Chili's Grill & Bar	3	10
8	Grocery Store	5	MC Alley Pharmacy	4	12
9	Previous	2	Matt's House	4	9
10	Fast Food	3	Lee's Famous Chicken	3	11
11	ATM	1	ATM (Canton)	3	7
12	ATM	1	Bank One	2	6

Part 3 – Test Trials While Driving West on M-14

Trial	List	Menu Position	List Item	Item Position	Total Keystrokes
13	Fast Food	3	Taco Bell	4	12
14	Address Book	1	Home	1	4
15	ATM	1	National City Bank	1	5
16	Gas Station	2	Consolidated Stations	5	10
17	Previous	2	Mom & Dad	2	7
18	Restaurant	3	Karl's Country Cabin	1	8
19	Grocery Store	5	Arbor Drugs	2	10
20	Address Book	1	Your best friend's house	3	6
21	ATM	1	Comerica	5	9
22	Grocery Store	5	Arbor Drugs	1	9
23	Grocery Store	5	Merchant of Vino	3	11
24	ATM	1	National City Bank	4	8

APPENDIX C – M-14 Test Route

The destination entry while driving took place on an 8-mile stretch of M-14 just northeast of Ann Arbor, Michigan (Figure 17). This stretch of rural expressway contained 2, 12-foot lanes in each direction separated by a grass infield. The posted speed limit was 70 mph and the annual average daily traffic on this section was 47,003 vehicles (according to the Michigan Department of Transportation, 1996). The traffic density during the experiment was light as all vehicles were moving at the posted speed limit.

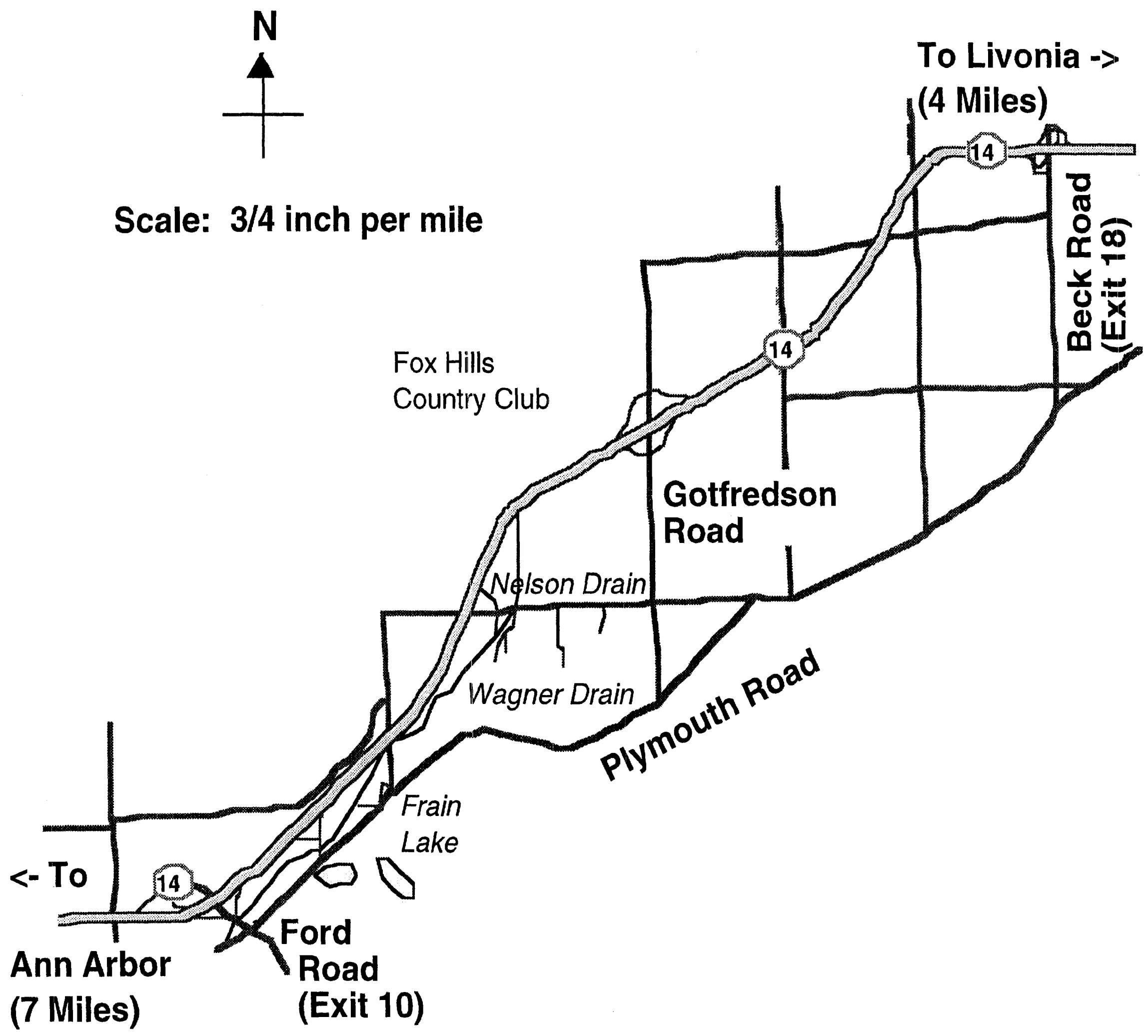

Figure 17. Graphical representation of the M-14 test route.

APPENDIX D – SAE J2365 Operator Elements

An operator is a keystroke-level subtask element. Table 6 shows the operator times specified in SAE J2365 (Green, 1999b). These values were based on the classical Keystroke-Level Model operators described by Card, Moran, and Newell (1980, 1983) that were obtained from a variety of office tasks. These estimates were based on office data that were likely to underestimate the task times because navigation data entry tasks are not well learned (i.e., not routine cognitive tasks) and because automotive workstation design does not permit rapid keyboard entry as in an office, even when the vehicle is stationary. The original model operators have thus been refined using data from Olson and Nilsen (1987) for spreadsheet use, and data from Manes, Green, and Hunter (1998) for entering data into a Siemens Ali-Scout Navigation System.

Table 6. SAE J2365 operator element times (seconds).

Code	Name	Description	Time (s)	Adjusted Time (s) (Note 1)
Rn	Reach near	From steering wheel to other parts of the wheel, stalks, or pods	0.31	0.56
Rf	Reach far	From steering wheel to center console	0.45	0.81
C1	Cursor once	Press a cursor key once	0.80	1.44
C2	Cursor 2 times or more	Time/keystroke for the second and each successive cursor keystroke	0.40	0.72
L1	Letter or space 1	Press a letter or space key once	1.00	1.80
L2	Letter or space 2 times or more	Time/keystroke for the second and each successive cursor keystroke	0.50	0.90
N1	Number once	Press the letter or space key once	0.90	1.44
N2	Number 2 times or more	Time/keystroke for the second and each successive number key	0.45	0.81
E	Enter	Press the enter key	1.20	2.16
F	Function keys or shift	Press the function keys or shift	1.20	2.16
M	Mental	Time/mental operation	1.50	2.70
S	Search	Search for something on the display	2.30	4.14
Rs	Response time of system-scroll	Time to scroll one line	0.00	0.00
Rm	Response time of system-new menu	Time for new menu to be painted	0.50	0.50

Note 1: The final column shows the data adjusted for the test user population (55-60) using the 1.7 multiplier (where appropriate).

SAE J2365 Calculations for Part 2 (Test Trials while Parked)

As shown in Table 7, total task-time estimates using J2365 were created for each of the 16 trials in Part 2 of the experiment (test trials performed while the vehicle was parked). Because the experimental timing of these tasks began after the first key (either the Destination or the Route button) was pressed, the total task-time estimates were also created starting at that point. After the first key was pressed (refer back to Figures 3 and 4 for a diagram of the entry tree), there were 5 steps:

1. Select the entry type (quickstop, address book, or previous destination).
2. Select the destination category if using the quickstop feature.
3. Select All or Fast Food if selecting a restaurant from quickstop.
4. Select the desired destination from the item list.
5. Press the OK button to confirm the destination and route preferences.

As an example for trial 1, the driver was instructed to select Dong Yu's China Market from the grocery store list. After pressing the Route button, the driver pressed Enter to select quickstop (denoted by the 1.2 second enter element under Entry Type). Next, the driver selected the category, grocery store, which was the fifth item in the list. This operation (under Category Select) required a first cursor keystroke (C1=0.8), 3 additional cursor keystrokes (C2) at 0.4 seconds for a total of 1.2 seconds, and an enter keystroke (E=1.2). Since the category was not a restaurant, no keystrokes were required under the All/Fast Food column. When the list of grocery stores appeared, the driver selected the target item which was third in the of items. This operation (under Item Select) required a first cursor keystroke (C1=0.8), a single additional cursor keystroke (C2=0.4), and an enter keystroke (E=1.2). Finally, to complete the entry, an enter keystroke was required (E=1.2) under the OK column. Adding all of these elements together, provided an estimated task time of 8.0 seconds.

Table 7. SAE J2365 calculations for the destination entry trials while parked.

Trial	Entry Type		Category Select			All/Fast Food		Item Select			OK	Total
	C1	E	C1	ΣC2	E	C1	E	C1	ΣC2	E	E	(s)
1		1.2	0.8	1.2	1.2			0.8	0.4	1.2	1.2	8.0
2		1.2	0.8		1.2			0.8	0.4	1.2	1.2	6.8
3		1.2	0.8	0.4	1.2		1.2	0.8	1.2	1.2	1.2	9.2
4		1.2			1.2			0.8		1.2	1.2	5.6
5		1.2	0.8	1.2	1.2			0.8	0.8	1.2	1.2	8.4
6	0.8	1.2						0.8	1.2	1.2	1.2	6.4
7		1.2	0.8		1.2			0.8	1.2	1.2	1.2	7.6
8		1.2			1.2			0.8	0.8	1.2	1.2	6.4
9		1.2	0.8	0.4	1.2	0.8	1.2	0.8		1.2	1.2	8.8
10		1.2						0.8	0.4	1.2	1.2	4.8
11		1.2	0.8		1.2					1.2	1.2	5.6
12	0.8	1.2								1.2	1.2	4.4
13		1.2	0.8	0.4	1.2		1.2			1.2	1.2	7.2
14		1.2	0.8	0.4	1.2	0.8	1.2	0.8	0.8	1.2	1.2	9.6
15		1.2			1.2			0.8	0.4	1.2	1.2	6.0
16		1.2	0.8	1.2	1.2			0.8		1.2	1.2	7.6