

ESTIMATING COMPLIANCE WITH THE 15-SECOND RULE FOR DRIVER-INTERFACE USABILITY AND SAFETY

Paul Green
Human Factors Division
University of Michigan Transportation Research Institute
Ann Arbor, Michigan 48109-2150 USA

This paper describes SAE J2365 (Recommended Practice for Calculating the Time to Complete In-Vehicle Navigation and Route Guidance Tasks), a draft procedure to estimate if the requirements of SAE J2364 (Navigation Function Access) are met. Application of these practices will enhance the safety, ease of use, and customer convenience of driver interfaces. SAE J2364 specifies that drivers should not be allowed to perform navigation-system tasks in a moving vehicle that take more than 15 seconds to complete when measured statically. Tasks are defined to start when the driver's hands begin to move from the steering wheel and end when feedback from the final-switch actuation is processed.

The 11-step calculation procedure of J2365 involves determining exactly how each task (e.g., destination entry) is carried out, developing a pseudo-code description of the goals and methods used, determining the associated elemental tasks, and adding up the task times. Elemental times [reaching for a device, keying (cursor, letter, space, enter), mental activity, searching, etc.] were derived from the Keystroke-Level Model (Card, Moran, and Newell, 1983) in the human-computer interaction literature, specific automotive studies of navigation data entry (Manes, Green, and Hunter, 1998), and MTM-1 (Barnes, 1968).

INTRODUCTION

Over the last 60 years improvements to motor vehicles -- electric starters, automatic transmissions, power steering, air conditioning, seat belts, air bags, etc. -- have been made at a steady pace. The recently introduced Intelligent Transportation Systems (ITS) program has led to a strategic change in vehicle innovation. The next 10 years, with the presumed wide scale introduction of devices such as adaptive cruise control systems, navigation systems, and collision warning systems, will restructure the driver's task. Emphasis will begin to shift from real-time control to information management.

Accordingly, there is concern that the information demands of these systems could overload drivers, with navigation systems being an initial concern. In fact, there is evidence that the probability of a lane departure is elevated when reading detailed maps (Nowakowski and Green, 1998) or when entering destinations into navigation systems (Tijerina, Parmer, and Goodman, 1998). Drivers are more likely to be involved in crashes when using cell phones (Goodman, Bents, Tijerina, Wierwille,

Lerner, and Benel, 1997) or when using in-vehicle systems with high visual demands (Wierwille, 1995).

Because of these concerns, the Society of Automotive Engineers (SAE) ITS Safety and Human Factors Committee has been developing standards to assure product safety and usability, both by design and assessment. One of its initial efforts is SAE J2364 (Recommended Practice for Navigation and Route Guidance Function Accessibility While Driving), which specifies what a driver should **not** be allowed to do with a navigation system in a moving vehicle (Green, 1999a,b,c; Society of Automotive Engineers, 1999). The scope of the Recommended Practice is limited to manual controls and associated visual displays. SAE J2365 (Recommended Practice for Calculating the Time to Complete In-Vehicle Navigation and Route Guidance Tasks, Society of Automotive Engineers, 1998) describes a procedure for estimating compliance with J2364. SAE J2365, the estimation procedure, is the focus of this paper.

THE 15-SECOND RULE (SAE DRAFT RECOMMENDED PRACTICE J2364)

As background, SAE J2364 states that any navigation-system task (such as entering a destination using a particular method) should not take more than 15 seconds to complete when measured as a continuous task. The 15-second limit represents the consensus view of the SAE ITS Safety and Human Factors Committee and its Navigation Subcommittee. The selection of the 15-second limit was based upon considerations of estimates of fatalities and injuries from long task times and glance sequences, existing design guidelines, current design practice, general human factors principles, human performance limitations, and other factors (Green, 1999a,b,c). Timing starts when the driver's hand leaves the steering wheel or moves toward the device and ends when feedback is provided for the last-switch actuation. There are modifications to the rule when tasks performed by the driver are computationally interrupted (i.e., the driver enters information and more than 1.5 seconds is required to display a response). Times are determined in a stationary vehicle or in a mockup.

During the Navigation Subcommittee meetings and those of the parent Safety and Human Factors Committee, there was considerable discussion of many alternative measures, particularly eyes-off-the-road time. Static task time was selected as the dependent measure because it (1) is correlated with eyes-off-the-road time which is in turn correlated with crash frequency (Wierwille, 1995), (2) is much easier to measure than alternatives such as eyes-off-the-road time, and (3) is computable early in development, thus supporting iterative design. Each of these points is expanded below.

First, on-the-road times should be estimable from static task times using an empirically derived workload multiplier (Green, 1999b,c). The estimated on-the-road task times can then be used to estimate eyes-off-the-road times. For that purpose, tasks should be divided into three categories: (1) continuous, (2) periodic, or (3) intermittent, with the multiplier decreasing as visual feedback becomes more central to task completion. For continuous feedback, vision is used to guide the control movement (e.g., inserting a CD, using a cursor to select a point on a map). For periodic feedback, vision guides switch selection, but the control actions are discrete (e.g., entering an address using an alphabetic keyboard, selecting the heat mode for a climate control system).

For intermittent feedback, vision is not required for every switch action (e.g., dialing a hand-held cell phone).

Second, to collect glance data, an installed, fully functional system or high-fidelity simulation is required, installed either in an instrumented vehicle or a driving simulator. The data reduction effort, generally manual, is both tedious and time consuming.

Third, glance-behavior studies are inconsistent with the rapid product cycles of ITS. Requiring such evaluations could make products with significant safety benefits too expensive to develop. In contrast, task times could be calculated and recalculated as the design evolves to identify user interface flaws and interface quality, especially during the conceptual phase when design changes are easy to make. As the product evolves, the task time calculations could also be used to check compliance with SAE J2364. Thus, this approach supports good design, and because the approach resembles traditional engineering, the approach is likely to be adopted by engineers.

SAE J2365 CALCULATION PROCEDURE

The calculation procedure developed has its origins in the Keystroke-Level Model from the human-computer interaction literature (Card, Moran, and Newell, 1980; 1983; Kieras, 1997; Olson and Nilsen, 1987-1988). This approach has conceptual origins in predetermined time systems (e.g., Methods Time Measurement, MTM) used by industrial engineers (Barnes, 1968).

There are 11 steps to the method in SAE J2365. The first three are to (1) obtain a working model, simulation, or step-by-step operational description of the device, (2) identify the major operational goals (e.g., obtain route guidance by entering a destination), and (3) for each goal, identify all subgoals.

In step 4, the methods used to complete each goal and subgoal are identified. Sometimes this may require observing a few users operating the device to determine a keystroke-level description of the method. The text description of the method is converted into a computer pseudo code in step 5. Figure 1 shows an example of searching for a particular city using the most popular navigation system in the U.S., the Magellan PathMaster (or

Hertz NeverLost), by scrolling through an alphabetized list of city names.

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wait for the beginning of the city list to appear
1: read highlighted item and decide if 1st letter of
current entry matches spelling of desired city
2: if first pass, then select method
/* pure or alphabetic scroll */
if not matching 1st letter then
    press bottom of round switch
    /* round switch is 4-way cursor */
    /* to go to next letter */
    go to step 1    /* decide if match */
                /* note: reading was earlier */
if matching 1st letter
    current letter = second letter
    compare current letter of highlighted item
    with spelling of desired city
    2.1 if current letter matches & last letter then
        confirm correct entry
        hit enter
        go to exit: next goal
    if current letter matches and not last letter then
        increment current letter
        go to 2.1    /* compare current letter */
    if current letter does not match then
        press key to scroll down 1 entry
        go to 2.1
exit: next goal

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Figure 1. Goal: Find a desired city name in an alphabetized list by scrolling.

In step 6, assumptions regarding each method are identified. These include (1) estimated times for system operations/computations (to scroll, update maps, calculate routes, etc.) and (2) assumptions regarding the method a driver might use. Times for system operations are included in the task time unless system operations are so long that a driver would discontinue the in-vehicle task and return to driving. For computationally interrupted tasks, the computational time is assumed to add 1.5 seconds to the total task time when feedback on task progress is provided. The 1.5 seconds allows for a single glance to check the task progress. When feedback is not provided, the entire computation time is included in the task-time estimate.

The Keystroke-Level Model assumes (1) the method used by subjects results in error-free performance (for computational ease) and (2) the actions executed constitute a routine cognitive task. Reasonable estimates for nonroutine tasks are obtained by using times for elements (e.g., keystrokes) that represent modest levels of practice. For a task to be routine, driver knowledge should be almost perfect. (Is the address Ann Arbor or Ann Arbor Township? Is it North or South 1st Street?) These subtle differences are often not known by drivers but are needed by navigation systems to provide guidance.

The J2365 procedure allows for the use of "visible" shortcuts. For example, a line on the display face plate connecting the function and address keys overwritten with the word "home" (to indicate a simultaneous keypress would select a home address) is a visible shortcut. Data of the frequency of use of shortcuts used is lacking.

To varying degrees, there may be departures from all of these assumptions for actual in-vehicle use by drivers. Nonetheless, the resulting engineering estimates are still good enough to assist in interface design and evaluation. Experimental checks of all assumptions are needed.

Steps 7 through 10 involve determining and entering the appropriate mental, keystroke, and other operators into a spreadsheet, adding them up, and making appropriate age adjustments. Table 1 shows the base operator times (for young drivers) and age-adjusted times (for ages 60 to 65) assumed to be the test sample in a previous draft of J2364. (The target age of J2364 is currently being debated with over 45 and 45-65 being the leading proposals, though middle-age samples have also been suggested.) The operators shown and their values emerged from a combination of the Keystroke-Level Model (Card, Moran, and Newell, 1980) in the human-computer-interaction literature, extensions of that model to automotive-specific tasks (Steinfeld, Manes, Green, and Hunter, 1996; Manes, Green, and Hunter, 1998), and MTM-1 (Barnes, 1968).

In step 11, rough checks of reasonableness are made, for example, comparing the estimates with data from a few pilot users.

Table 1. Operator Times (seconds)

Code	Name	Description	Base Time (s)	Age-Adjusted Time (s)
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

The author believes that application of this method is fairly straightforward and provides useful first-cut engineering approximations for task times. Case studies (for real interfaces) are desired to verify and improve estimates of operator times. In addition, estimates for visual task times specific to this context (e.g., reading text, viewing maps) are desired. Some estimates could be developed using the published literature (Namba, 1980; Brooks and Green, 1998; Brooks, Lenneman, George-Maletta, Hunter, and Green; Green, 1999b,c). Also needed are performance estimates (in particular, for glance durations and frequencies) for computationally interrupted tasks. In those tasks, the navigation system communicates with an off-board device, such as a traffic information service. When that occurs, a message often appears ("processing") as well as an indicator of estimated completion time. In response, drivers periodically check the visual display to determine if the processing is completed so they can complete the task. Finally, the effect of using a HUD instead of an instrument panel display on data entry task completion times, both static and while driving, needs to be considered.

Although improvements and enhancements are desired, the estimation procedure described provides useful insights into improved driver interface design, for a relatively modest effort, and in a manner consistent with common engineering practice.

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