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# The 15-Second Rule for Driver Information Systems

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## ABSTRACT

The 15-Second Rule specifies the recommended maximum time for drivers to complete navigation-related tasks involving visual displays and manual controls in a moving vehicle. Compliance is determined by calculating task time assuming the vehicle is parked, a simplifying assumption. Task time is (1) correlated with crash risk, (2) much easier to measure than alternatives such as total eyes-off-the-road time, and (3) is computable early in development, thus supporting iterative design. This rule is the basis for a proposed Society of Automotive Engineers (SAE) standard (J2364) and a related international standard to promote the safety and usability of driver interfaces. A compliance standard (SAE J2365) and a related international standard for compliance are under development.

The 15-Second Rule (1) is consistent with existing national and trade association guidelines, (2) is consistent with accepted vehicle design practice and, (3) more generally, minimizes harm to drivers. Designers should realize that a good case can be made for lower task time limits (e.g., 10 seconds) to further reduce opportunities for interface-induced crashes, and achieving that limit is desired where feasible. A practical result of the 15-Second Rule is that most destination entry tasks will not be allowed in moving vehicles.

The process of developing this rule also provided useful insights into general practices for creating Intelligent Transportation System (ITS) standards. In particular, the use of consultants is recommended to accelerate standards development. Further, standards should be based on human factors guidelines and research as interpreted by human factors experts, not interested parties, and emerge from a process true to SAE Technical Standard Board rules.

## INTRODUCTION

The goal of the ITS initiative is to make travel more efficient, safer, and more enjoyable to the public. To achieve these benefits, ITS products must be safe, usable, and useful. Desired ITS product characteristics are more likely if there are product benchmarks to guide the design. Common benchmarks are standards from the SAE and ISO (International Standards Organization).

This paper describes both the particulars of a specific standard and the process by which a consensus was achieved, a process with implications for all ITS standards. The standard described in this paper was developed with funding provided by the U.S. Department of Transportation (USDOT) to the SAE. The funding allowed for a departure from the old, costly, adversarial process of legally-mandated standards to expediting commercial, consensus standards more appropriate for rapidly developing areas such as ITS. The funding was used to hire consultants who would assist volunteers from subcommittees of the SAE ITS Safety and Human Factors Committee to develop six sets of standards. Work on the first set, for which author served as a consultant, began in the spring of 1997. That set will specify what drivers should <u>not</u> be allowed to do with a navigation system in a moving vehicle (SAE J2364) as determined by task time calculations (SAE J2365) (Society of Automotive Engineers, 1998a, 1998b). Since the safety and usability of speech interfaces in motor vehicles is not well understood, SAE J2364 only applies to interfaces that incorporate manual controls and visual displays. Thus, the standard does not consider voice-activated controls, voice output from the navigation system, communication between the driver and others, or passenger operation.

SAE J2364 and J2365 will serve as the U.S. proposals for ISO standards, standards that could apply to any in-vehicle information system.

During the development of this standard, five major questions arose in the following order:

1. Why is this standard needed?
2. Why should the standard be based on performance?
3. Why should task time be the performance measure?
4. Why should the task time limit be 15 seconds?
5. Why should the results be a standard and not a recommended practice or an information report?

## WHY THIS STANDARD IS NEEDED

Many ITS in-vehicle systems involve tasks that are far more complicated than common driver tasks such as operating the horn, lights, or wiper switches, and, consequently, could distract drivers. For navigation systems, data entry and retrieval can take longer than tasks associated with complex radios and climate control systems, or the task of dialing a phone. The USDOT reviewed the safety of mobile phones (Goodman, Bents, Tijerina, Wierwille, Lerner, and Benel, 1997), and reported safety to be marginal. In some countries, use of a phone while driving is illegal. For some members of the Navigation Subcommittee, this indirect evidence was sufficient to indicate the need for a standard.

Three key documents provided the foundation for the development of a standard. The author produced a review of the relevant literature (Green, 1998). That review, (1) refined the scope of the standard, (2) examined the relationship between crashes and in-vehicle tasks, (3) summarized studies on destination designation, (4) free viewing times, and (5) typical in-vehicle glance durations, and (6) developed predictive relationships between glance measures, task time, and the number of lane departures. Draft copies of the report served to keep the Subcommittee informed of progress.

When this project was funded, there were no published on-the-road studies concerning data entry into navigation systems in moving vehicles, though there were relevant laboratory studies (Loring and Wiklund, 1990a, 1990b; Paelke, 1993; Paelke and Green, 1993; Steinfeld, Manes, Green, and Hunter, 1996; Manes, Green, and Hunter, 1998). However, the study reported by Tijerina, Palmer, and Goodman (1998) during the initial year of this program was pivotal in moving SAE J2364 forward. Tijerina's subjects drove on a test track with traffic while operating one of four commercial navigation systems. For interfaces with visual displays and manual controls, the mean entry time was 40 seconds to 2 minutes (depending on the driver age group) and the mean number of lane departures was 0.9. While drivers were entering an address, they usually left the lane. As a comparison, the number of lane departures for dialing a mobile phone or tuning a radio was 0.1 to 0.2, and task times were between 15 and 20 seconds.

Also critical was an evaluation of the relationship between in-vehicle task demands and crashes (Wierwille, 1995). Post-crash narratives recorded by the police in the North Carolina state data base helped identify causal factors in crashes. "I was adjusting my radio, so I did not see the other car." Based on the literature, an equation was developed predicting the number of involvements in crashes as a product of the component frequency of use, mean glance duration, and the number of glances per use.

Finally, in recent meeting, there has been mention of data from the Japanese National Policy Agency suggesting the use of navigation systems can contribute to crashes (Tsuda, 1998). Only a brief summary of that effort was presented to the Navigation Subcommittee and a detailed report was not available for critical review. Further, the nature of the interference (route guidance, data entry, or both) has not been identified. Nonetheless, this evidence does highlight the need for a standard.

Thus, studies have shown that (1) navigation data entry tasks take far longer than common in-vehicle tasks, (2) completing such tasks while driving frequently induces drivers to depart from their lane, and (3) tasks of these durations are associated with a calculable, elevated crash risk. This does not mean that navigation systems are undesirable overall, only that some tasks are of concern.

## WHY A PERFORMANCE STANDARD AND NOT A DESIGN STANDARD

The charge from both the SAE committee and the ISO working group was to develop a design-based standard. This charge proved difficult to implement. For example, there was mention of the distraction afforded by scrolling through long lists of street names or city names while driving. To identify an acceptable list length, a performance measure was required, so ultimately the standard had to be performance based. There were not enough product variations on the market and information on product histories to allow for a compilation of navigation-induced crashes by product feature. Furthermore, problems with particular interfaces could be due to how they were implemented now and banning a class of designs could discourage innovation. During the fall of 1998, a consensus for a performance-based standard emerged.

## WHY TASK TIME SHOULD BE THE PERFORMANCE MEASURE

Given that there was agreement to develop a performance-based standard, a measure or measures had to be selected. An ideal measure of safety and usability should (1) truly reflect driver safety and interface usability, (2) not constrain innovation, (3) be easy for designers and engineers to understand, obtain, and apply, and (4) be acceptable to safety and human factors experts within the SAE and ISO. There are many candidate measures (Green 1995a) such as the NASA Task Loading Index (TLX), time-to-line crossing (TLC), the standard deviation lane position, and measures of visual occlusion, though eyes-off-the-road time is mentioned most often. Unfortunately, this measure is very expensive to obtain (Green, 1995b), so expensive that some products with potential safety benefits would not be developed.

One of the key findings of the report on visual demand (Green, 1998) was the high correlation between task time and total eyes-off-the-road time (R2 = 0.96), a predictor of crash frequency. The task time can be estimated by multiplying total glance time by 1.6 for moderately difficult driving conditions. Further, task time is readily obtained using the Keystroke-Level Model (Card, Moran, and Newell, 1980). Such estimates are most useful during the early iterations of the design when changes are readily made, rather than as a post production check. In fact, only a conceptual description of the interface is required, not a fully functional system installed in a vehicle (as would be required to collect eye fixation data). Thus, use of task times and the supporting validation method would improve product quality and aid, not burden, designers.

## WHY THE TIME LIMIT SHOULD BE 15 SECONDS

The next step in the process, defining and selecting a maximum task time, was reasonably straightforward. A single level criterion was selected as specified in the project contract. Further, reaching agreement on multiple levels of acceptability was not feasible.

To be consistent with the literature and to simplify implementation, a task was defined to begin when a hand or finger left the steering wheel and to end when feedback from the last control actuation was received. A task is an activity that has a useful impact on a person's driving. Hence, for existing navigation systems, the destination entry task includes entry of the number, street name, and city (and possibly the routing strategy, e.g., the fastest route), since all are required to compute a route. Since times for in-vehicle tasks while driving (dual task performance) can be predicted from single task performance using a workload multiplier, task times are calculated from static conditions (a parked car or a laboratory simulation) for ease of implementation. There is also a provision for computationally-interrupted tasks, those situations where the driver must wait more than a fraction of a second for the system to respond. For example, some systems allow for drivers to select points of interest such as restaurants and gas stations as way points during a trip. Sometimes there is a delay of a few seconds between when the driver presses the point of interest button and when the locations appear on a map for further selection.

In selecting a time limit, the key principles were (1) minimizing harm to the driver, (2) consistency with existing standards (e.g., British Standards Institution, 1996), (3) consistency with current design practice, and (4) utilization of the human factors literature. The Navigation Subcommittee began with the position that 60 seconds was clearly too long, 3 seconds was too short, and the standard should fall somewhere in between. As shown in Table 1, the evidence available can be used to support maximum times in the range of 9 to 12 seconds. However, the desire was to select a time that would represent a consensus of the experts on the Subcommittee (in this case, the entire Subcommittee) would agree was too long, and a few committee members felt 12 seconds was too short. To provide for a margin of error, a compromise value was 15 seconds was selected. However, designers should note that shorter durations promote safety and usability, and should aim towards them (e.g., 10 seconds).

Table 1. Some of the Evidence Considered for the 15-Second Rule

| **Principle** | **Comment** |
|---|---|
| Do not add to the risk of driving | Tijerina, Palmer, and Goodman's (1998) evaluation of destination entry showed almost one lane departure per trial for trials of almost one minute or more. Hence, task times in excess of one minute are clearly not acceptable. |
| Follow accepted guidelines | The guidelines developed by Battelle for the USDOT (Campbell, Carney, and Kantowitz, 1997) support restricting access when task times exceed 10 seconds. |
| Follow accepted guidelines | The JAMA guidelines (Japan Automobile Manufacturers' Association, 1996) allow for a maximum of 31 characters for VICS traffic information. If messages are about 80% Chinese characters and 20% alphabetic, and each alphabetic character is 2.2 bits of information and each kanji is 10.85, then each 31 mixed character message would be the equivalent of a 128.5 alphabetic characters. At 7 characters per word, the longest message allowed is 18 words. When not time sharing, people can read two to three words per second. Assuming 2 words per second and not time sharing, the estimated longest time is 9 seconds. |
| Consistency with accepted practice | The author's replotting of the Zwahlen diagram (Green, 1998) of the Dingus and Wierwille data shows that conventional controls and displays have mean glance times of less than 1.3 seconds and 7 glances, on average, for a product of 9.1 seconds. Based on Tijerina, Palmer, and Goodman's (1998) data, about 80% of the trial time is spent looking inside the vehicle. This would suggest a worst case task time of 11.4 seconds (=9.1/0.8). |
| Consistency with accepted practice | Destination entry was not allowed while moving in the TravTek or ADVANCE interfaces, nor is it allowed in products sold by Toyota in the U.S. or in the Ford Mondeo sold in Europe. Task times are typically on the order of one minute or more for the street address or intersection methods of destination entry. |

Note: Though yet to be formally discussed, the maximum number of words suggested for highway signs and the reading times for highway signs may be a consideration.

During development of the standard, discussion of the reference user population (e.g., young vs. older drivers) did arise as the reference population has an important influence on the difficulty of achieving compliance (and the appropriate task time limit). The standard assumes the sample represents a reasonable worst case for the target market, drivers 55-60 years old who have not used a navigation system in a vehicle they have driven regularly. To provide a level of expertise consistent with that target user sample, drivers, either simulated or real, are assumed to be provided with the customer instructional materials (e.g., users' manual, quick reference card, instructional video or audio tapes) and allowed to complete each task five times prior to testing (or have an equivalent level of expertise).

Thus, at of the end of 1998, the Subcommittee accepted the 15-Second Rule in principle, and the committee draft of SAE J2364 was ready for voting. The supporting report was then being completed, and the first draft of SAE J2365 (the validation standard) was drafted and presented to the relevant ISO Working Group (ISO Technical Committee 22, Subcommittee 13, WG 8 -- Ergonomics of Road Vehicles, Transport Information and Control Systems). All documents were posted on the SAE web site (www.sae.org/TECHCMTE/safety.htm) early in 1999. The plan at that time was to finish this project in mid-1999, depending upon when the Subcommittee agreed to a draft of SAE J2365.

## WHY THIS RULE SHOULD BE A STANDARD

The SAE process can generate an SAE Standard, a Recommended Practice or an Information Report. In this case, there is ample evidence to support a standard, far more evidence than has been used to support standards for symbols, message set priorities, or adaptive cruise control features, instances where standards are in place or about to be approved.

## LESSONS LEARNED FROM THE DEVELOPMENT PROCESS

There is much more to this story than how SAE J2364 emerged and why. Of particular importance are lessons on how to develop commercial human factors standards with direct product impact. The seven selected lessons that follow reflect both the author's personal experience as a consultant to this program and his observations of the interactions of other consultants working with the ITS Safety and Human Factors Committee.

**1. The basic process is good.** The current process was open to all parties, more congenial than past practice, and relied on technical expertise to make decisions in a timely manner.

**2. The streamlined consultant selection process proceeded quickly.** Had this effort been handled directly by the USDOT, consultants would have been required to submit detailed supporting documentation that would have been costly for consultants to produce and for the government to review. Here, the ITS Safety and Human Factors Committee identified the top two or three experts relevant to each standard, with the expert favored by the committee being invited to submit a proposal. Factors considered were the experts' knowledge of the general topic, their experience in research on automotive applications, their ability to work with the committee, and their availability.

**3. The description of the proposal content needs refinement.** Contract negotiations did not proceed swiftly. There was some uncertainty as to what proposals should contain, and the repeated interactions to resolve those uncertainties delayed the process.

**4. The use of a consultant was key to making progress.** Funding a consultant expedited setting the standard. Reviewing the supporting literature was a major effort, much more than could be done by a volunteer. The ongoing editing of drafts of the standard to reflect reviewer comments was also a task requiring time and technical expertise. Without a consultant, developing a standard would have taken many more years.

**5. Support contracts should be for three to five years, the time required to develop and approve a standard.** Experience has shown that once a subcommittee has a complete draft of a standard, they may require six months to one year to agree upon a draft, if they meet once a month or every other month to discuss it. The committee responsible for navigation standards only meets once every three months, so if more than one revision is requested, six months or more can easily elapse. At the international level, the relevant ISO working group only meets twice a year. Given the usual desire for revisions and the general nature of the SAE and ISO processes, development of a vehicle ergonomics standard typically requires three years if there are no delays. To assure follow-through on a standard, funding for three to five years is recommended.

**6. Make decisions based on the process guidelines.** During early stages of the development of the standard, debates arose within the Navigation Subcommittee regarding acceptance of the research evidence, the goals of the standard, and so forth. These problems were largely overcome by applying the process guidelines shown in Table 2. (See Green, 1998 for details.)

Table 2. Example Process Guidelines

| Guideline | Explanation |
|---|---|
| When in doubt, err on the side of safety. | This guideline was the subject of considerable debate. (Do no harm. Do minimal harm. Do more good than harm. Minimize harm.) Where the implications of evidence were debated, this guideline helped the subcommittee reach decisions. |
| Emphasize the literature over personal experience. | The average driver will have far less knowledge of a navigation systems than subcommittee members. Hence, the tendency to think "I can do this so..." may not be best for the general public. |
| All studies are not equal. | Weigh the evidence based on its quality, comprehensiveness, and technical relevance. |
| Support the harmonization of SAE and ISO standards. | The ideal situation is when national and international standards are the same, so products can be designed to one set of standards. When conflicts occur, international standards usually take precedence. Harmonization can be fostered when the same people develop both sets of standards (hence, international travel is required) and when standards bodies show flexibility to support harmonization. |
| The USDOT is watching. | In many ways, the use of commercial standards by the government is an experiment. If meaningful standards that protect the public do not emerge from this program, the old adversarial process could be reinstated. |
| Members of the SAE committees and subcommittees serve as independent technical experts as specified by the SAE Technical Board Rules. | In the initial meetings, some attendees were under pressure to act as representatives of their employers, not as independent technical experts. |
| Decisions regarding human factors issues (standards content and voting) should be made by human factors experts, not interested parties, especially at the subcommittee level. | Input from a wide range of individuals is desired. However, since ISO standards are required for type approval in some countries, ISO standards can effectively become legal requirements. Therefore, the identification of experts should be consistent with how an expert is determined in a court of law, that is an expert witness. This understanding is implicit in the SAE process and is one reason why the government is willing to accept commercial standards. |

**7. Make sure the data compilation effort is complete before writing a standard.**

There was considerable pressure to produce a draft standard early in the project. Had a draft standard been produced before all of the evidence was assembled, a consensus would not have been achieved.

## CLOSING COMMENT

This paper explains how the 15-Second Rule evolved, why the Rule makes sense, and suggests how subcommittees should operate to expediently develop consensus ITS engineering standards. Despite of the innovative benefits of this program, the earmarking of USDOT funds effectively eliminates the flexible funding the USDOT needs for future support of ITS standards development, a decision warranting reconsideration. This is a disappointing ending for a good idea and will diminish the safety and usability of future ITS products.

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