Driver Interface/HMI Standards to Minimize Driver Distraction/Overload

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ABSTRACT

This paper describes (1) the telematics distraction/overload problem, (2) what distraction and overload are and how they differ, (3) the standards and guidelines that apply to the design and evaluation of driver interfaces/human-machine interfaces (HMI) for telematics (and their strengths and weaknesses), and (4) what standards and research are needed to support the development of driver interfaces. Most of the paper is a detailed discussion of evaluation standards, in particular SAE Recommended Practices J2364 (Task Time and Occlusion Tests) and J2365 (Task Time Estimation), ISO Standards 16673 (Occlusion Test) and 26022 (Lane-Change Test), and the AAM Driver Focus Guideline.

INTRODUCTION

WHAT IS THE PROBLEM? With the increasing focus in society on productivity, time in transit is viewed as wasted time. Therefore, there is great pressure for people to do more than just drive when driving—participate in conference calls, handle email, surf the web, and so forth, both for business and personal purposes. However, the crash data and common experience suggest this is, at best, unwise because drivers are not giving their full attention to driving. This problem will grow as the equipment to enable communication with drivers in moving vehicles becomes more capable and less costly.

Furthermore, there is also an increase in the number of systems to support driving (collision warning and avoidance, adaptive cruise control, lane departure, etc.) and their complexity is increasing. Each of these systems has an interface for the driver to set and monitor, which can be burdensome.

Although these systems are intended to be beneficial to drivers, there are many instances where they can and have distracted drivers from the primary task of driving and overloaded them.

WHAT TERMS AND CONCEPTS ARE RELEVANT TO THIS TOPIC? In the popular literature, this situation is referred to as the driver distraction problem, which is somewhat of a misnomer. But popular literature is not always the most authoritative source for science and engineering. A useful discussion of distraction and overload appears in Oberholtzer, Yee, Green, Eoh, Nguyen, and Schweitzer (2007), summarized in the section that follows.

The Merriam-Webster Online dictionary (http://www.m-w.com/cgi-bin/dictionary) defines distraction as, " **1 :** the act of distracting or the state of being distracted; *especially* **:** mental confusion, **2 :** something that distracts; *especially* **: AMUSEMENT."** Furthermore, it defines distract as, "**1a :** to turn aside **: DIVERT b :** to draw or direct (as one's attention) to a different object or in different directions at the same time, **2 :** to stir up or confuse with conflicting emotions or motives."

Other definitions, cited by Tosca (2005) appear in Table 1. One common theme is that distraction draws, diverts, or directs the driver's attention away from the primary task of controlling the vehicle. In more extreme cases, distraction can also refer to a situation where a task is given inordinate attention—the task grabs and retains the driver's attention, often out of proportion to its importance.

However, there are other instances in which the term distraction is used, but overload is intended. To understand overload, some knowledge of theories of human attention is warranted. According to the Multiple Resource Theory (Wickens, 1984: Horrey and Wickens, 2003), people are considered to have a variety of resources (visual, auditory, cognitive, and psychomotor) they can allocate to a task or combination of tasks. Overload can occur when the task demand exceeds at least one of the resources or, in less common cases, the capability to switch between tasks. So for example, people cannot read two high data rate, nonredundant streams of text separated by a large visual angle because their eyes cannot be directed towards two widely separated locations at once. Similarly, people cannot retain nonchunkable long strings of digits in

memory because that would overload the cognitive resource, specifically, short-term memory.

Table 1. Definitions of driver distraction from Tosca (2005)
(Source: Yee, Nguyen, Green, Oberholtzer and Miller, 2007, page 2)

Source	Definitions as cited by Tosca (2005)
Ranney, Garrott, and Goodman, 2000	"Driver distraction may be characterized as any activity that takes a driver's attention away from the task of driving. Any distraction from rolling down a window to using a cell phone can contribute to a crash… four distinct categories of distraction: - Visual (e.g., looking away from roadway) - Auditory (e.g., responding to ringing cell phone) - Biomechanical (e.g., adjusting CD player) - Cognitive (e.g., lost in thought)."
Stutts, Reinfurt, Staplin, and Rodgman, 2001	"Distraction occurs when a driver is delayed in recognition of information needed to safely accomplish the driving task because some event, activity, object or person (both inside and outside the vehicle) compelled or tended to induce the driver's shifting attention away from the driving task (citing Treat, 1980)."
Beirness, Simpson, and Desmond, 2002	"Need to distinguish distraction from inattention…Distracted driving is part of the broader category of driver inattention. Presence of a triggering event or activity distinguishes driver distraction as a subcategory of driver inattention."
Green, 2004	"'Driver distraction'" is not a scientifically defined concept in the human factors literature. As used by the layperson, it refers to drawing attention to different object, direction or task. A distraction grabs and retains the driver's attention."
Tosca, 2005	"Distraction occurs when there is… a voluntary or involuntary diversion of attention from primary driving tasks not related to impairment (from alcohol/drugs, fatigue or a medical condition). Diversion occurs because the driver is: performing an additional task (or tasks) or temporarily focusing on an object, event or person not related to primary driving tasks. Diversion reduces a driver's situational awareness, decision-making and/or performance resulting in any of the following outcomes—collision, near-miss, corrective action by the driver and/or another road user."

Even if the secondary task has fairly low demand, that task may cause an overload if the driver is near the limit of his or her information processing capability (for example, because the traffic is demanding). Drivers deal with overload in many ways—allowing the quality of performance of primary or secondary tasks to decline, shedding tasks entirely, delaying the start of tasks, and so forth. Of particular concern is when such adaptation affects the primary task of driving.

In some cases, multiple tasks are truly performed in parallel whereas in others what appears to be parallel is actually rapid switching between tasks in much the same way that a timesharing computer functions with interrupt service routines and their associated overhead.

This overload situation is quite different from the attraction situation described previously, as are the strategies used to deal with it.

Consistent with general usage, this paper concerns both distraction and overload together, even though from scientific perspective they are related, but different phenomena.

WHAT ARE THE CONSEQUENCES OF DISTRACTION AND OVERLOAD? - If a driver's attention is drawn away from the primary task of driving, or they are overloaded beyond their capabilities, crash risk is elevated. This is well established by crash data for cell phones (Redelmeier, and Tibshirani, 1997; Laberge-Nadeau, Maag, Bellavance, Lapierre, Desjardins, Messier, and Saïdi, 2005; McEvoy, Stevenson, McCartt, Woodward, Haworth, Palarnara, and Cercarelli, 2005), human performance data for phones use while driving (Caird, Scialfa, Ho, and Smiley, 2006; Horrey and Wickens, 2006), and crash evidence for navigation. (See also Makishita and Mutoh, 1999; Stutts, Feaganes, Rodgman, Hanlett, Meadows, Reinfurt, Gish, Mercadante, and Staplin, 2003; Neale, Dingus, Klauer, Sudweeks, and Goodman, 2005; Stutts, Feaganes, Reinfurt, Rodgman, Hamlett, Gish, and Staplin, 2005; Eoh, Green, Schweitzer and Hegedus, 2006; Green, Wada, Oberholtzer, Green, Schweitzer, and Eoh, 2007.) The problems identified for destination entry for navigation systems will also occur for entertainment and other in-vehicle systems if the exposure and the intensity of the visual, manual, cognitive, and/or psychomotor demands are similar. (See Yee, Nguyen, Green, Oberholtzer, and Miller, 2007.) That outcome is consistent with theories of human attention.

Beyond the formal scientific observations, most drivers have observed other drivers who are driving erratically—somewhat oblivious to other traffic, wandering in their lane, etc. If observed at night, such drivers are probably drunk. If observed during the day, they are probably on the phone. Knowing that such degraded driving poses considerable risk to others, such drivers are avoided. Drivers pass them, fall behind, or change a different

lane, anything to not be near them. However, such disruptions to the traffic stream present risks, though probably less risk than driving in close proximity to those with degraded driving performance.

WHAT CAN BE DONE TO PREVENT THE CRASHES AND INJURIES INDUCED BY DISTRACTION AND OVERLOAD?

From time to time one hears the mantra, "Drivers are responsible for their own actions." It is a true statement. However, under the principles of strict liability, and accepted legal practice, manufacturers and suppliers must design products for <u>foreseeable and expected use and misuse</u>. Those unhappy with such principles often refer to perverse situations as counterarguments, such as the unverified legend of a manufacturer being sued by an injured person for failure to warn against using a

lawnmower as a hedge clipper (http://www.snopes.com/legal/trimmer.asp), drivers who drive with cups of hot coffee between their knees (the MacDonald's case), etc. However, the situations of interest here are much more common, especially visual-manual tasks such as dialing long distance phone numbers not using speed dial, entering navigation destinations using a street address method, creating mp3 playlists, and so forth. These are tasks that systems allow drivers to do, and that designers know they will do, but that are quite disruptive to driving.

Table 2 lists the strategies for dealing with driver distraction/overload. Of those listed, licensing constraints are believed to be effective for younger drivers. Banning use while driving, minimizing risk with a workload manager, and designing out hazards can be effective as well.

Table 2. Strategies for dealing with distraction/overload

Strategy	Description	Comment
Selection	Test drivers using some set of in-vehicle devices and only allow drivers to use those devices for which they achieve some desired score.	Who would conduct these tests, and who would enforce the results is uncertain.
Training	Classes could be created to teach drivers how to timeshare with devices while driving.	Consumers are unlikely to want to pay to be taught how to talk on the phone and drive. Furthermore, the evidence from driver training is that basic driving expertise can take hundreds if not thousands of hours to achieve. Skill in multitasking occurs after that.
Licensing	Drivers are legally forbidden to perform certain tasks (using the phone) while learning to drive.	Some graduated driver licensing programs currently include provisions for these constraints, mostly related to cell phone use. When an adult driver, often a parent, accompanies the learner, there is some reasonable prospect of enforcement.
Ban	Have laws that make the use of some devices while driving illegal.	Several states have laws restricting hand-held phones, but not hands-free phones, even though the crash risks are similar. Those laws have exceptions for law enforcement and other urgent uses. Total bans are strongly opposed by the cell phone service providers.
Minimize risk with a workload manager	A workload manager is a hardware/ software system that determines the workload the driver is experiencing at any given time and, based on the estimated workload, decides what the driver is permitted to do (for example, by locking out certain functions).	Volvo and a few other brands have simple workload managers installed in their vehicles to control cell phone use. See Green (2004), Green (2006), and Schweitzer and Green (2007) for details. A workload manager provides selective availability of cell phones and other communication devices, a highly desired characteristic.
Design out hazards	To design out the hazard, human factors specialists examine each task and determine the method and devices to be used to complete each task along with the information to be presented.	Human factors specialists often rely upon design standards and guidelines for making decisions. Those documents are the focus of this paper.

WHAT MAKES FOR A GOOD STANDARD OR GUIDELINE?

The focus of this paper is on designing out hazards. The quality of guidelines and standards for that purpose

depends upon both the quality of the final guideline or standard and the process by which it was developed, most of which follow the widely accepted canvass process (http://www.ansi.org/standards_activities/overview/overvi

This process is used by the American National Standards Institute (ANSI), and the International Standards Organization (ISO) and many national standards bodies. The five elements of the process are (1) consensus output, (2) input from those affected or interested, (3) broad public review, (4) consideration of comments, and (5) the right to appeal.

1. CONSENSUS OUTPUT - The final document should represent the broad view of those participating in the process. Where there are divergent views, time may be required to develop a compromise that suits everyone.

2. INPUT FROM ALL MATERIALLY AFFECTED OR INTERESTED PARTIES - For automotive safety and usability standards, this not only includes manufacturers and suppliers, but also consumer groups, motorist associations, representatives of insurers, the press, academicians engaged is research or design, members of standards organizations, government regulators, and, of course, the general public. Sometimes the role of regulators is uncertain because there may be constraints on participation in nongovernmental regulatory-like activities.

3. BROAD-BASED PUBLIC REVIEW OF DRAFT STANDARDS - For this to occur, there need to be (1) requests for comments need announced in places that interested parties are likely to see them, (2) a place to submit comments, and (3) sufficient time to respond. If comments are to be made in person, then travel requirements to get to the site need to be reasonable. For example, overseas travel should not be needed. To obtain sufficient review, sometimes comments may need to be solicited.

4. CONSIDERATION OF AND RESPONSE TO COMMENTS SUBMITTED - A point-by-point discussion of each comment is needed, not merely an acknowledgment that comments were received. Applicable comments should be incorporated into revisions of the draft standard.

5. RIGHT TO APPEAL - Anyone involved in the process can appeal if they believe that due process was not sufficiently respected during the standards development.

In addition, there is a need for a significant effort to assure that those drafting the standard are recognized technical experts. In some cases, such as SAE, those experts are bound to serve independently of their employer by SAE rules.

WHAT STANDARDS AND GUIDELESS EXIST?

There are two groups of standards and guidelines: (1) specific automotive safety and usability standards and (2) generic standards for the same purposes. Furthermore, those standards can be process-, performance-, or design-oriented. The process standards often provide an overview of user-centered design. The performance and design standards are more specific. Guidelines, which provide advice on how interfaces should be designed, have been developed by a variety of organizations, often under contract to the U.S. Department of Transportation. Standards, which specify how things must be done, are usually developed by standards development organizations. Guidelines and standards are covered separately in the section that follows, based largely on the information in Green (2008). Some of the standards that address distraction/workload never actually use those words anywhere in them.

GUIDELINES - There are quite a large number of guidelines that are automotive specific. (See Schindhelm, Gelau, Keinath, Bengler, Kussmann, Kompfner, Cacciabue, and Martinetto 2004 for an overview.) Guidelines can be divided into 4 categories. The first includes the detailed design guidelines funded by the U.S. DOT – the UMTRI guidelines (Green, Levison, Paelke and Serafin, 1993, 111 pages) and the Battelle guidelines (Campbell, Carney, and Kantowitz, 1997, 261 pages) – and those funded by the EU – the HARDIE guidelines (Ross, Midtland, Fuchs, Pauzie, Engert, Duncan, Vaughan, Vernet, Peters, Burnett, and May. 1996, 480 pages).

The second category has its origin in the EU Guidelines, later renamed the European Statement of Principles. It includes the original set of 24 brief guidelines (Commission of the European Communities, 1999, 2 pages), the 35 principles (Commission of the European Communities, 2005, 59 pages), and a later checklist (Stevens, Board, Allen, and Quimby, 1999, 18 pages) and guidelines (Stevens, Quimby, Board, Kersloot, and Bur, 2002, 70 pages) from the Transport Research Laboratory (TRL). (See also Stevens, 2008.)

The third category is actually just a single document, the 15-page JAMA guidelines (Japan Automobile Manufacturers Association, 2004). In some ways the JAMA guidelines are more restrictive than other guidelines. (See also Akamatsu, 2008)

The fourth category contains guidelines/standards written by the International Standards Organization. They cover dialogue management (ISO Standard 15005:2002E), procedures for auditory presentation (ISO Standard 15006:2004), visual behavior measurement (ISO Standard 15007:2002E, parts 1 and 2), legibility (ISO Standard 15008:2003), the warnings literature (ISO Technical Report 16352:2005), message priority (ISO Trial Standard 16951:2004), and the suitability of interfaces while driving (ISO Standard 17287:2002). Standard 17287 is somewhat different from the others as it describes a process to assure safety and usability, not specific design or test requirements.

For additional information on all of these guidelines, see Green (2008).

There are also a large number of general-purpose guidelines that could apply to automotive products. The best known of these is Military Standard 1472F (U.S. Department of Defense, 1999), which many consider as the human factors bible. The document is strongest in covering traditional controls and displays, but weak in covering computer interfaces.

Also of somewhat general relevance are the Federal Aviation Administration Human Factors Design Standard (Federal Aviation Administration, 2003) and section 12 (workstations) of the NASA Man-Systems Integration Standards (National Aeronautics and Space Administration, 1995). Similar to the 1472 standard, these general design standards are sometimes not current in terms of their coverage of human-computer interfaces. For human-computer interfaces, readers may find the ISO Standard 9241 (Ergonomics of Human System Interaction) to be more useful. Of this 17-part document, parts 9 (requirements for non-keyboard devices), 10 (dialogue principles), 14 (menu dialogues), and 17 (form filling dialogues) should be most relevant to automotive applications.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) STANDARDS - SAE is recognized as the leading worldwide organization of automotive engineering. SAE follows the ANSI canvass process. SAE develops information reports (summaries of the literature), recommended practices (how something should be done), and standards (how something must be done), all of which somewhat confusingly are sometimes referred to as standards. The should/must distinction between recommended practices and standards can be misleading as compliance is voluntary. However, any organization involved in a products liability action is unlikely to win if they are not in compliance with either type of document.

SAE Recommended Practice J2364 (Green, 1999b; Society of Automotive Engineers, 2004a,b) describes two test methods (static, occlusion) and criteria to determine if visual-manual tasks should not be performed while driving. Speech tasks demand different resources and therefore have a different pattern of interference with driving. The scope statement limits the application of J2364 to navigation, but J2364 should apply to any system with visual-manual tasks. Interference with driving depends on the frequency, the duration, and the intensity of demands for each resource for each instance of each task, not the system with which it is associated, per se.

The static test procedure requires 10 test subjects between the ages of 45 and 65, which means that the reasonable worst case of elderly drivers is not considered. The argument was made that older subjects are too difficult to recruit, which is not true.

Each subject completes five practice trials and three test trials of the task of interest (e.g., entering a street address) in a parked vehicle, simulator, or laboratory mockup. Although the ultimate interest is when drivers do these tasks dynamically (while driving on the road), there is a high correlation between static and dynamic task times, and static task times are much easier to collect. Depending on the driving situation, on-the-road task times are approximately 1.3 to 1.5 times the static times.

For the static method, the maximum acceptable time is less than 15 seconds (hence the name, "The 15-Second Rule"). The rule does not mean that one can continuously attend to a task (and continuously look away from the road) for 15 seconds while driving. In fact, when driving and performing secondary tasks, drivers alternate between the primary task of driving and secondary tasks.

The criterion for the static method is the antilog of the mean of the logs of the task times, a computation designed to reduce the influence of outliers. To minimize the risk of distraction/overload, the author would recommend a 10-second criterion. There have been comments about evaluations finding tasks just above or below the 15-second limit, and that being good or bad, depending on one's perspective. Keep in mind that the task times determined using J2364 or any other method are not the true times, just estimates, though some estimates are better than others. In such discussions, measures of variability should also be considered, so a reasonably wise designer could use common statistics to compute Type I and Type II errors to provide a sense of their confidence in the results, should their calculations be challenged.

A strength of the static method is that compliance with the 15-second limit can be predicted using a calculation procedure described in SAE Recommended Practice J2365 (Green, 1999a; Society of Automotive Engineers, 2002) based on task element times (keying, mental operations, etc., Table 3) from the widely accepted GOMS (Goals, Operators, Methods, and Selection Rules) model from the human-computer interaction literature (Card, Moran, and Newell, 1983) and adjusted for automotive applications. The process by which an analysis is performed is well defined and readers are encouraged to see the Recommended Practice for implementation details. (See also Manes, Green, and Hunter, 1998; Nowakowski and Green, 2001; Pettitt, Burnett, and Karbassioun, 2006 for supporting literature.) Task time calculations take less time to complete and can be done early in design well before a prototype exists, when the design is easy to change. All too often, when tests are done at the end of a program, the response is, "We know it failed the safety/usability test, but we need to ship in two weeks, so we ship as is." Engineers rely on calculations for making design decisions, and driver interface engineering should be similar.

Table 3. Elemental times (s) from SAE J2365

Code	Name	Description	Time (s)	
			Young Drivers (18-30)	Older Drivers (55-60)
Rn	Reach near	from steering wheel to other parts of the wheel, stalks, or pods	0.31	0.53
Rf	Reach far	from steering wheel to center console	0.45	0.77
C1	Cursor once	press a cursor key once	0.80	1.36
C2	Cursor >= 2 times	time/keystroke for the second and each successive cursor keystroke	0.40	0.68
L1	Letter or space 1	press a letter or space key once	1.00	1.70
L2	Letter or space >= 2 times	time/keystroke for the second and each successive cursor keystroke	0.50	0.85
N1	Number once	press the letter or space key once	0.90	1.53
N2	Number >=2 times	time/keystroke for the second and each successive number key	0.45	0.77
E	Enter	press the enter key	1.20	2.04
F	Function keys or shift	press the function keys or shift	1.20	2.04
M	Mental	time/mental operation	1.50	2.55
S	Search	search for something on the display	2.30	3.91
Rs	Response time of system-scroll	to scroll one line	0.00	0.00
Rm	Response time of system-new menu	for a new menu to be painted	0.50	0.50

Also in J2364 is an occlusion method in which the device is visible for 1.5 seconds and occluded for 1 to 2 seconds, with 1.5 seconds being recommended. (See Foley, 2008.) The method is usually achieved by having subjects wear goggles with an LCD lens (Figure 1) that can block vision of the device. The intent of the method is to simulate the process of intermittently looking back and forth between the road and an in-vehicle display. Timing starts when the subject is told to start and ends when the last control associated with the task is operated. The criterion (again determined using logs) for this method is 20 seconds of vision (the total unoccluded time) or 13-1/3 1.5-second periods. Recently, Pettitt, Burnett, and Stevens (2007) have proposed a calculation for estimating compliance, a major advance.

Personally, if given the choice, the author would use the J2365 procedure and then the static method, if resources were available to check selected results. If asked to use the occlusion method, the author would first use the Pettitt et al. method to calculate compliance, only checking compliance for those tasks that were close to the performance criterion.

For perspective, keep in mind that a task is an activity with a goal that is achieved using a specific method. So, if goal is to enter a destination, then entering that destination using the street address is a different task from using a point of interest (POI) because the methods are different.

Figure 1. Occlusion goggles (Source: Wilbur, 2004)

INTERNATIONAL STANDARDS ORGANIZATION (ISO) STANDARDS – ISO activities related to distraction/overload are carried out primarily by Technical Committee 22/Subcommitee 13 (Ergonomics of Road Vehicles), in particular Working Group 8. Compliance with ISO standards is voluntary. However, in some countries, to be type-certified for sale, vehicles must comply with ISO standards. Therefore, for international marketing, manufacturers and suppliers conform to ISO standards. Furthermore, in a product liability context, noncompliance with accepted practice (ISO standards) is not good for those defending a product.

ISO has two standards that specifically have the word distraction is their title, ISO 16673:2007 (Occlusion method to assess distraction) and ISO 26022 (Lane change test to assess distraction, which at this time is a committee draft, not an approved standard).

ISO 16673 applies to all visual and visual-manual interfaces for which the static task time exceeds 5 seconds. The procedure involves at least 10 licensed drivers not familiar with or technically knowledgeable of the driver interface in question. (The intent is to use "ordinary drivers" as test subjects, not, for example, navigation system designers.) ISO 16673 requires at least 20% of the test subjects be over age 50. In practice, since the number tested is likely to be the

minimum, that means 2 subjects over age 50.   The interface in question is explained to subjects and they are given two to five practice trials, at least two of which involve using the device in an occlusion condition. Occlusion is achieved using LCD goggles or a similar device, with vision and occlusion intervals both being 1.5.   Subjects are then split into two groups, half of whom complete a static condition followed by occlusion, and half who complete the conditions in the opposite order. For each condition, there are five test trials. The key dependent measures are the static total task time and the total shutter open time for each trial.

In addition, the standard also describes the resumability ratio, an indicator of how well a task can be resumed after interruption. In brief, the ratio is the total shutter open time divided by the static total task time and resumability ratios greater than 1 are "an indication that the participants may be having difficulty in resuming the task after an interruption" (page 10).   The actual calculations are more complicated, provide for removing outliers, and describe computing other statistics.

The resumability ratio has been the subject of some discussion. Artificial tasks have been created that vary in their R values with tasks with large values negatively affecting driving, but there is less evidence for actual driving tasks. Furthermore, the use of R is based on the hypothesis that drivers partially complete tasks and then

resume them. Although drivers look back and forth between the road and the in-vehicle task, it is not well established that much longer interruptions with resumptions occur in naturalistic driving, and with some frequency.

So, in many ways ISO 16673 is parallel to SAE J2364, as both require static and occlusion data be collected. However, 16673 differs from J2364 in one very critical way. ISO 16673 has no acceptance criteria for safety or usability, and this is a major weakness. A defensible position would be to be consistent with SAE J2364, static task times of not more than 15 seconds, total occlusion times of 20 seconds, and, as suggested by 16673, an R value of not more than 1. However, the author would argue for a static task time of 10 seconds.

Those involved with research will have a sense of what values are acceptable. Keep in mind that one group carrying out such evaluations will be designers in tier 2 suppliers, some of whom will have no human factors background, not even an introductory undergraduate class or a continuing education short course such as the one taught at the University of Michigan (http://www.umich.edu/~driving/shortcourse/index.html).

Some have argued that there should be no safety criteria because knowledge of what is safe is incomplete. If that is the case, then these products should not be sold to consumers, who have even less knowledge and resources to assess the safety of products. They assume the product has been established to be safe for their use.

ISO CD 26022 is a draft procedure developed as part of the ADAM program. The procedure, the Lane-Change Test, was developed to be driving-like, but not require a full-fledged driving simulator or a test vehicle. There is no common software or methods for specifying driving scenes in detail, so creating consistent test conditions for simulator or real-world situations is very difficult. The test procedure developed commonly uses a PC, special software, and a specific steering wheel and foot controls used for video games (Figure 2). The system has, however, been installed in mockups and real vehicles (Figure 3), a huge advantage. The hardware is readily available and the software can be obtained from Mercedes for free.

The scene is of a three-lane road, with signs showing the lane in which the subject should drive (indicated by chevrons) and not drive (indicated by X, Figure 4). The road is 3 km long, enough for 3 minutes of driving at 60 km/hr (and 18 lane changes or 2 minutes of data collection). The subjects' tasks are to change lanes as quickly as possible when indicated by signs that pop up 40 m ahead of them while they are completing in-vehicle task.

Figure 2. Setup of lane-change test using game controller

Figure 3. Examples of the lane-change test installed in a mockup and a real vehicle
(Source: Hallen, 2006)

Figure 4. Lane change test road scene as per ISO indicating a change from the middle to right lane
(Source: International Standards Organization, 2004)

The most recent discussion has been that there should be 20 subjects, but details concerning age, training, and so forth have yet to be resolved. Notice this is a larger sample than called for by other standards, but a number needed to obtain the desired statistical power. The current proposal also contains information on the experimental design: when baseline (no secondary task) data is collected, how much practice should be provided, how to counterbalance conditions, etc.

At this point, there is still a great deal of discussion as to what the performance statistic should be. Candidates include the mean deviation from the desired path, the area of the deviation from the desired path, the standard deviation of the distances between the two paths, statistics related to differences in the onset of the two path changes, secondary task completion time, secondary task errors, the number of incomplete tasks, and so on. There is interest in a composite statistic. The selection process has emphasized the correlation between the maneuver statistics and other statistics, as well as ease of computation. (See Figure 5.) Less consideration has been given to which maneuver statistics should theoretically be most indicative of crash risk.

For additional information, see Mattes (2003), Burns, Trbovich, McCurdie, and Harbluk (2005), Hallen (2006), Ohtani, Uno, Asoh, Iihoshi, and Marunaka (2006), Harbluk, Burns, Lochner, and Trbovich (2007), and Mattes and Hallen (2008).
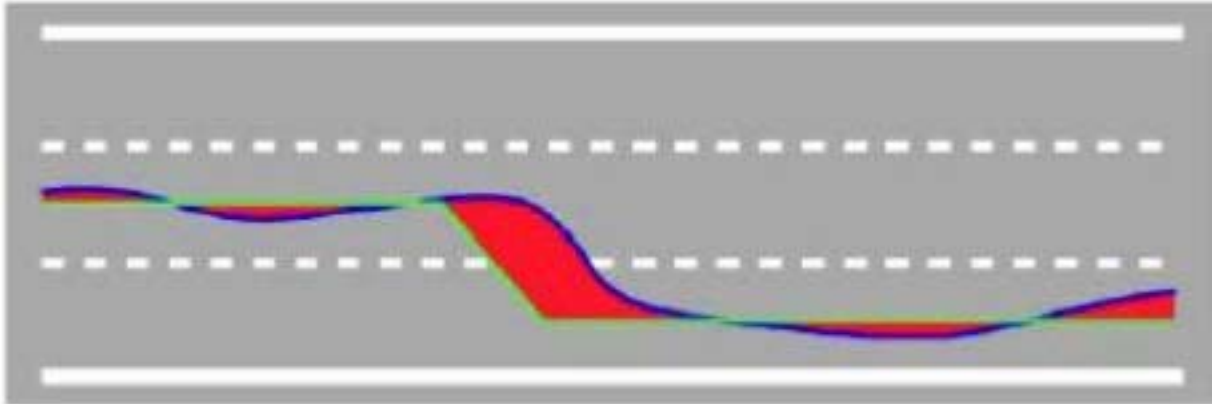

Figure 5. What should be the dependent measure of performance in the lane change task?
(Source: Hallen, 2006).

ALLIANCE OF AUTOMOBILE MANUFACTURERS (AAM) GUIDELINES - The AAM guidelines are a very detailed (67 page) elaboration of the original EU principles, with each guideline containing rationale, criteria, verification procedures, and examples. The latest approved version is version 3. The scope is limited to "advanced information and communication systems intended for use by the driver while the vehicle is in motion" and "are not intended to apply to traditional information or communication systems, nor to new collision warning or vehicle control systems at this time" (page 9). As is noted elsewhere in this paper, human performance theory argues degradation depends on the task characteristics, not the name of the system, which argues for applying the AAM guidelines to all driver interfaces.

In some ways the AAM guidelines resemble the other guidelines described previously in that they provide advice on how aspects of interfaces should be designed; that is, design guidance. That is reflected in its title. However, AAM guidelines resemble the SAE and ISO standards in that they specify a process for assessing the safety/usability of a driver interface. However, they differ in one very critical way: SAE and ISO standards were developed following an open canvass process, while AAM meetings are open only to AAM members and there are no opportunities for public discussion of AAM proposals.

For the purposes of this paper, principle 2.1 is the most important. It states, "Systems with visual displays should be designed such that the driver can complete the desired task with sequential glances that are brief enough not to adversely affect driving" (page 23).

Two alternative sets of performance criteria are proposed. For alternative A, they are: (1) single glance durations generally should not exceed 2 seconds (page 23) and (2) task completion should require no more than 20 seconds of total glance time to task display(s) and controls (page 23). For alternative B, they are: (1) the number of lane departures should not exceed those for reference tasks such as manually tuning a radio under normal driving conditions and (2) following distance or time variability should not be worse than when reference tasks are being carried out. Compliance for either alternative can be verified by having subjects drive on a divided highway, at 45 mi/hr or less, during the day, on dry pavement, with low to moderate traffic. How the reference radio task should be conducted is described in great detail.

For both alternatives, the requirement is to test an equal number of men and women ages 45 to 65 who are not familiar with the interface in question. After training, subjects are given two practice trials followed by two test trials.

For alternative A, an occlusion procedure is described with an open shutter time of 1.5 seconds and a closed time of 1.0 seconds, slightly different from ISO (1.5 and 1.5 seconds, respectively). "If a task can be successfully completed with total shutter open time $\leq$ 15 sec (with reasonable statistical confidence), the task would be considered to meet both criteria A1 and A2. This is based on the expectation that a task generally successfully completed within 15 seconds total shutter open time will seldom exceed the criteria A1 and A2 under real-world driving conditions" (page 36).

Also described for alternative A is an eye monitoring procedure in which the criterion are a mean task glance duration of $\leq$ 2.0 sec for 85% of the test sample and a mean total glance time to perform a task is $\leq$ 20 sec for 85% of the test sample.

For alternative B, a test track is specified.

For those interested in a detailed review of the AAM guidelines, see Go, Morton, Famewo, and Angel (2006).

WHAT SHOULD DESIGNERS DO?

Clearly, there are an overwhelming number of guidelines and standards to consider and it is foreseeable that ISO will develop additional test methods. Where should designers start?

Good interface design is not merely a matter of complying with specific design requirements but must also include a process in which genuine attention is given to safety and usability. More than anything, this means following the Gould and Lewis (1985) design principles: (1) early focus on users and tasks, (2) iterative design, and (3) test, test, test.

What does early focus on users and tasks mean? For users it means getting detailed statistical data on users, such as age, sex, domain knowledge, the number of prior systems they have used, etc. Developers might even want to consider creating personas (Pruitt and Adlin, 2006).

However, information on tasks is generally lacking. For example, consider a navigation system. How often does the user enter an address and how often is each method to achieve that goal (street address, intersection, point of interest, favorites, etc.) used? How many of each type of address are in the user's list of favorites? Designing an easy-to-use interface is extremely difficult when there is no statistical data on how it is or could be used.

The next step, creating a prototype, begins with a crude version of the user interface, often drawn on paper (Snyder, 2003) and may be followed by simulations in PowerPoint.

In any case, it is important to get responses on how real drivers would use the interface, not the engineers in the next cubicle. Those early tests help identify interface concepts real drivers will not find easy to use. Feedback from each round of driver testing is used to refine the interface, and increasingly more detailed prototypes are developed, with the final testing occurring in a simulator or on the road. The key to an easy-to-use system is not the total number of people tested, but the number of rounds of testing and revision.

An important part of the testing process is the development of benchmark data. How easy to use should the new version of the interface be? Should it be at least as good as the previous version? Should it be better than the competition? Of course, this requires the identification of core tasks, performance statistics relating to task time, errors, and user satisfaction, and a standard protocol for assessment.

How does the material presented here fit into the Gould and Lewis process? With the first step, the paper helps very little. In fact, the human factors literature does contain information on how often various devices are used, as was described earlier. However, what is lacking from the literature are details concerning how often various tasks are performed. How often do drivers enter destinations using a street address?

The literature provides a significant amount of information to support iterative design, especially concerning so-called "dials and knobs human engineering." However, most of the performance improvement will come form the grouping of functions, their layout, and the selection of computer interface widgets, some of which is covered in ISO 9241.

But the issue here is not just whether the information available, but who is given the task to do it. To develop easy-to-use/safe-to-use driver interfaces, one needs trained experts, who may be called human factors engineers, ergonomists, usability specialists, or have a host of other titles. One should not expect an electrical engineer with no coursework in human factors to design an easy-to-use interface any more than one would expect the history major to be good at electrical engineering. That means that organizations need to hire people with coursework in human factors, advanced degrees on the topic, and those certified by the Board of Certification in Professional Ergonomics (www.bcpe.org).

As was emphasized earlier, an important part of the design process is calculating user performance, estimating the time to select items from menus and dialog boxes, read text, and so forth. SAE J2365 is

ideally suited for this purpose. Furthermore, so too is the computation of visual demand using the method of Pettitt, Burnett, and Stevens (2007).

The final step is testing, and as emphasized by Gould and Lewis (1985), one test is not enough. Of the methods that exist, the author would begin with the static method of J2364 because it is easiest to do and because task times are well correlated with many other measures of distraction/overload. If fact, for the initial rounds, the static method is the only test method the author would use as it is likely to identify most of the problems that need correcting. Again, the time limit is 15 seconds. The other methods can be useful, but two rounds of static tests (with modifications made after each one) are more likely to lead to a better user interface than one round involving a more extensive test battery (followed by modifications).

In the final round, the author would recommend considering using the occlusion method to check the static test data, and cross-check all of those data with the J2365 predictions and the Pettitt, Burnett, and Stevens (2007) estimates. Setting the occlusion and viewing times both to 1.5 seconds should comply with the SAE Recommended Practice, the ISO Standard, and the AAM requirements. There are compliance requirements both in SAE and AAM to consider.

It could very well be this final round of testing is not conducted. The need for it will depend on the scope of the program, the resources (people, funds, equipment, time) available, and how well the interface does in the static testing per J2364. If static tasks times are, for example, 6 seconds or less, further testing is not going to be needed.

Notice that use of the AAM methods and the lane change task is not strongly advocated at this time. The author's best estimate is that it will be some time before the AAM methods are defined as well as others described here. With the Lane-Change Test, there is still a great deal to be done to reach consensus on the appropriate performance measure and the acceptance criterion. To date, the quality of work on this method has been good, but there is more to do, in particular to link performance to crash data, occlusion, and task time.

It must be emphasized that these recommendations about testing must be viewed from the context of each organization. If the project manager who makes decisions about what will be made does not believe in a method ("I think occlusion is quackery"), then no matter how good the science, results from testing are unlikely to have the desired influence. Organizational dynamics are important.

WHAT IS NEXT?

To address the overarching problem, distraction/overload of in-vehicle systems, further work is needed (1) directly related to distraction/workload assessment, and (2) to provide a fundamental understanding of distraction/workload phenomena.

ACTIVITIES DIRECTLY RELATED TO DISTRACTION/ WORKLOAD ASSESSMENT

1. Complete ongoing work on the lane-change test - ISO is working on this. To make the test truly useful, performance criteria are needed.

2. Begin development of a test based on the peripheral detection task - The reaction to this could be, "Oh no, not another test." However, within the automotive human factors community there is interest in this task and, most importantly, there is research evidence that has shown there are aspects of task demands independent of total task time (Young and Angell, 2003; Young, Aryal, Muresan, Ding, Oja, and Simpson, 2005)

3. Continue to advance the calculation methods - There has been refinement of the human performance elements in most predictions (Williams, 2005) and new information on which to base corrections for age (Jastrzembski and Charness, 2007). Those additions complicate the prediction models, taking more time to complete, but should provide more precise predictions. However, is very little data on application error when using the models, something given considerable attention in the predetermined time systems used by industrial engineers (e.g., MTM).

4. Carry out case studies on how interfaces are actually designed - Currently, there are a fair number of sets of design guidelines and standards for assessing distraction and workload, but nobody knows how they are actually used (and what it will take to get them used). For example, the U.S. DOT and the EU spent a great deal of funds on the UMTRI, Battelle, and HARDIE guidelines, and their development identified knowledge gaps in the literature. Certainly, the existence of safety guidelines and standards encouraged designers and engineers to think about safety, but the effect of these documents on the design of real products is unknown.

There are at least three cases to consider, (1) the major auto manufacturers with significant human factors experts on staff (e.g., Ford, GM, Nissan, Toyota, etc.), (2) the major suppliers who are trying to sell to the major manufacturers but have more limited resources but greater incentive to provide innovative driver interfaces (e.g., Visteon, Delphi, Bosch), and the tier 2 and 3 suppliers who may have no human factors staff and much less awareness of guidelines and standards.

The temptation is to address this topic via surveys, which are likely to be uninformative. What is desired is the rich detail that might be obtained from a longitudinal contextual inquiry.

5. Collect data on task frequency – As was mentioned earlier, to design an easy-to-use interface, the tasks for which the interface is to be used need to be known. This data could be obtained from field operational tests, special instrumented system trials, and possibly surveys. One of the difficulties is that some of the data will be product specific and manufacturers and suppliers may be reluctant to want the data to be public. However, without information on how often tasks are done, decisions about what drivers should and should not do will be based strictly on task characteristics, not on how often those tasks are performed, which ignores important aspects of exposure.

6. Develop performance criteria for all distraction/workload tests – Some have argued against performance criteria in standards claiming (1) the perfect answer is not available and (2) the decision of what is safe should be the manufacturer's/supplier's decision. Although perfect answers do not yet exist, the measurement protocol is not very useful if there are no criteria for assessment. Furthermore, of the world's leading technical experts, the people who may be in the best position to establish criteria are those who conducted the research, read the literature, and have the best access to the scientific evidence: those on the ISO committee. If those experts cannot agree as to what is safe, then products for which safe levels of performance are not identifiable should not be sold. If the human factors experts cannot make the assessment, how can the public do so?

MORE FUNDAMENTAL WORK TO UNDERSTAND DISTRACTION/WORKLOAD PHENOMENA

7. Develop a quantitative link between crash risk and human performance measures - One of the struggles with all of the distraction/workload test protocols is establishing a criterion level for unacceptable performance. So, if the standard deviation of lane position increased by say 10% in some driving context, what would happen to crash risk? At this point, the only known connection is that using a cell phone, either hand-held or hands-free, increases crash risk by a factor of 4. The work of Lerner (2005) might help stimulate thinking on this topic.

8. Develop a quantitative model of the workload of driving - As part of the SAVE-IT program, UMTRI has developed equations that reliably predict the subjective workload of driving using data ordinarily collected by ACC and navigation systems (Schweitzer and Green, 2007). As this point, those equations have not been validated on the road and there is no data for nighttime or inclement weather, which is needed.

9. Develop human performance models of workload – Driver interfaces are being engineered without the necessary scientific base, a huge weakness. As was noted in Green (2006), what is needed is a theory about how people timeshare and carry out tasks while driving.

There have been proposals based on systems such as ACT-R, COSMODRIVE, QN-MHP, and so forth, but none is sufficiently advanced for practical use. The lack of such models makes it much more difficult to solve practical engineering problems, and in the minds of some, makes automotive research and engineering appear to be second class.

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