

The Human Interface for ITS Display and Control Systems: Developing International Standards to Promote Safety and Usability

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Abstract

This paper provides an overview of topics that need to be addressed in developing standards for driver interfaces of the future. To provide context, this paper identifies 14 characteristics of a successful standards development effort (e.g., minimal work item overlap, adequate working group expertise, achievable compliance). The paper then reviews the current work program of International Standards Organization Technical Committee 22, Subcommittee 13, Working Group 8 (Ergonomics of Road Vehicles-Transport Information and Controls Systems - ISO TC 22/SC 13/WG 8). Multiple perspectives (human information processing, safety, etc.) are used to identify gaps in the WG8 standard program. Needed are standards for (1) excess visual demand, (2) excess cognitive demand, (3) interruptions that supercede driving, (4) auditory information, (5) workload managers, (6) telephone interfaces (especially those with Bluetooth features), (7) personal digital assistants (PDAs), (8) large area head-up displays (HUDs), and (9) wearable computers. Where feasible, standards should not only include assessment procedures but design data and methods as well.

Although the WG 8 experts have been engaged in an extensive effort to develop standards, there is more work than they can handle, and their workload is increasing. To provide the needed personnel and research information, greater effort is needed to recruit participants from the new and now more significant organizations in the automotive industry--tier 1 suppliers, electronics suppliers, service providers, computer companies, and the telephone companies. A significant and immediate increase in research funding to support standards development is also needed. Opportunities to expand use the web to disseminate information should be explored.

Introduction

The electronic content of motor vehicles has grown considerably over the last few years and projections for the future are for continued growth (Richardson and Green, 2000). Electronics

have become a larger cost fraction of core vehicle components such as engines and transmissions (as controllers) and are present as new systems, such as those related to Intelligent Transportation Systems (ITS), specifically telematics. As vehicles change, so will driver tasks and the driver interfaces for those tasks. An important part of the effort of promoting the safety and ease of use of those interfaces is the development of international standards.

The purpose of this paper is to identify (1) the characteristics of automotive standards that make them successful, (2) to briefly review the work program of ISO TC 22/SC 13/WG 8, and (3) to determine where ISO driver interface standards for telematics applications are needed to assure safety and usability. These thoughts are based upon the author's 25-year experience as a member of various SAE human factors committees and subcommittees, and ISO TC 22/SC 13/WG 8, as well as his research on driver interfaces. Although the emphasis is on WG 8 efforts, many of the ideas presented apply to any technical committee. To illustrate current concerns, special attention is given to (1) SAE Recommended Practice J2364 (Green, 1999c,d; Society of Automotive Engineers, 2000), also known as the 15-second rule, (2) the associated calculation protocol (SAE J2365) (Green, 1999a,b), and (3) the evolution of a related international standard.

There are far more requests for driver interface standards than can ever be successfully addressed with the limits of TC 22/SC 13 and, presumably, TC 204/SC 12. Therefore, those subcommittees need to continue to consider what will be required to develop a standard and what will be its ultimate impact when they establish a work program. The thoughts in this paper are intended to assist such deliberations.

What Makes for a Readily Achieved Standard?

There are at least 14 requirements that need to be considered when a work item for a standard is proposed. Satisfying those requirements ensures standards will be developed in a timely manner and useful when implemented. Those requirements concern (1) relevance, (2) clear assignment of responsibility, (3) data indicating a need for the standard, (4) clear scope and undisputed content, (5) minimal work item overlap, (6) adequate working group expertise, (7) content that is specific, (8) multicountry development, (9) commitment to explore options, (10) support for design and evaluation, (11) reasonable compliance assessment, (12) achievable compliance, (13) ultimately making a difference, and (14) anticipating the future.

1. Is the Topic Relevant to the Technical Committee and Subcommittee?

For a standard to be developed, the topic must be relevant to the technical committee acting on it. The scope for ISO TC 22 (www.iso.ch/meme/TC22.html) encompasses, "all questions of standardization concerning compatibility, interchangeability, and *safety* (author's emphasis), with particular reference to terminology and test procedures (including the characteristics of instrumentation) for evaluating the performance ... of road vehicles and their equipment..." Thus, TC 22/SC 13 has safety and usability issues as its mandate, and should not be reluctant to state so (as in the case of the suitability DIS). Recently, TC 22/SC 13/WG 8 used the relevance requirement as the reason to forward an item concerning railway crossing warnings to TC 204 because WG 8's responsibility is primarily inside the vehicle.

2. Is There a Clear Assignment of Responsibility to the Technical Committee?

At one time, there were difficulties in coordinating ergonomics activities between TC 204/SC 12 and TC 22/SC 13. These difficulties were resolved by jointly attended meetings and memoranda of understanding. Because subcommittees and working groups do not meet very often, sometimes just twice a year, finding a common time and place to meet that satisfy international constraints is not easy.

3. Is There Adequate Data to Identify the Need for a Standard?

Persuasive evidence for an automotive ergonomics standard can consist of data showing crash risk, usability problems with real products, or similar evidence. For example, during the development SAE of J2364 (the 15-second rule), the lane departures, long eyes-off-the-road times, and long task times reported by Tijerina, Parmer, and Goodman (1998) supported the need for a navigation standard. However, standards developers need to balance the desire for having unequivocal evidence for a standard with the consequences (in terms of crash deaths) of waiting until that evidence has accumulated. For telematics, most states in the United States do not provide codes on their accident forms to record whether use of a cellular phone was evident, and there are no plans to provide codes for the use of navigation, adaptive cruise control, or other systems. Thus, other evidence may be needed to argue for telematics safety standards.

4. Is the Scope Clear and Content Undisputed?

Writing the scope of a standard requires input from many parties, though in an attempt to secure broad input, scope statements sometimes have a committee-like style, with long sentences and lots of modifier terms, so as to include ideas from everyone. In creating the scope, some thought needs to be given to what the standard will achieve.

National and cultural differences can increase the difficulty of establishing a standard for some purposes, such as definitions. For example, there are differences in the way English is used in the United States and Europe, and the need for multilingual definitions complicates matters. For some items, such as maps for navigation, there are significant differences between the United States, Europe, and Japan in the way they are used, so a common standard may not be achievable.

5. Is There Minimal Overlap with Other Items in the Work Program?

This overlap can occur when both general and system-specific evaluation protocols are being developed, confusing potential users and overloading the limited pool of experts (who work on developing both protocols at the same time).

6. Does the Working Group Have Sufficient Expertise to Develop a Standard?

In TC 22/SC 13, consideration of a proposal for a standard begins with creating a task force or working group of experts with relevant technical knowledge from at least 5 countries. Finding

such expertise (and adequate travel budgets) among WG 8 members is not always possible. The French have been working on the development of an ISO proposal for auditory devices but progress has been slow because of a lack of experts from other countries, in particular, the United States. Where the 5-expert requirement cannot be met, delegations are encouraged to develop standards within their own national bodies as a precursor to subsequent ISO efforts.

7. Is the Standard's Content Specific?

Real design involves tradeoffs. When tradeoffs are made, quantitative criteria (e.g., the product should have depth of less than 5 cm) almost always take precedence over qualitative criteria (the product should be easy to use). It is therefore critical that standards include quantitative criteria (such as the 15-second rule) where feasible.

General criteria are primarily useful to experts. For example, the author and his colleagues have found the principles in the UMTRI guidelines for driver information systems (Green, Levison, Paelke, and Serafin, 1993) useful for evaluating real navigation systems (e.g., Nowakowski, Utsui, and Green, 2000), but the principles are rarely invoked by designers.

8. Are Multiple Countries Included in the Development Process?

Delegations must be kept informed of developments, and their input must be valued. When comments are scarce or delegations are silent, delegations should be called upon for comments. By making development collective, approval is much more likely.

9. Is There a Commitment to Collect Data Comparing Alternative Solutions?

Information is needed to select criteria levels in standards, but gathering that information can be delayed until development is underway. The information could be a synopsis of the current literature or new research findings produced while the standard is developed. A commitment of people and funds to gather the information is essential. Unfortunately, many of those on TC 22/SC 13 (and presumably TC 204/SC 12) do not have discretionary resources to address standards questions. The lack-of-data problem has been most acute in TC 22/SC 13/WG5, where many symbols have been included in ISO standard 2575 (for automotive symbols) without any empiric testing or engineering analysis of their legibility or understandability. Legibility analysis often takes the form of presenting a proposed image on a transparency to the committee, defocusing the overhead projector, and making a snap committee decision concerning the image legibility.

In contrast, the U.S. Department of Transportation has funded consultants to collect background research information (e.g., Green, 1999b, d) and write draft SAE ITS standards, allowing committee experts to concentrate on the review of proposals. Although consultants were barred from conducting research, the use of funded consultants has accelerated standards development (by years) and improved the quality of the standards developed.

10. Does the Standard Support Design and Evaluation?

Human interfaces to computers have become easy to use, in part because interface concepts have been evaluated for usability early in design. The earlier in the design the evaluation is conducted, the more likely that changes can be made. In support of this idea, SAE J2365, the companion to J2364, contains a method for estimating task time based on task elements (keystrokes, thinking time, etc.). Thus, compliance with the 15-second rule can be determined when the interface concept is just a sketch on the back of an envelope. Furthermore, J2364 also contains a specific evaluation protocol describing the selection of test subjects, practice, etc. that can be used to determine compliance.

11. Is Compliance Assessment Reasonable?

Where unlimited resources have been available, engineers have been able to create instrumented vehicles, driving simulators, and test tracks with extraordinary capabilities. However, resources spent on expensive evaluation protocols are not spent on something else, and the time to complete such protocols can delay introduction of a product with considerable safety benefit. Evaluation methods are desired that are simple, quick, and inexpensive, but also provide validity and suggest improvements to designs (Green, 1995). Consequently, an eye-fixation-based protocol was not included in SAE J2364 because the equipment required is expensive, the expertise to use it highly specialized, and the time required to collect and reduce eye-fixation data is considerable.

12. Is Compliance Achievable?

This consideration arises more often in government standards (e.g., the U.S. corporate average fuel economy, CAFE) than ISO standards. There are times, however, when there can be disagreement about the appropriate level of performance to achieve compliance. For example, designing a keyboard-based interface for which a street address or intersection can be entered in 15 seconds is difficult. Effectively, this constraint prohibits some destination-entry tasks in moving vehicles.

In establishing safety criteria, the level of protection desired must be specified (do no harm, do more good than harm, minimize harm to the driver, etc.).

13. Will the Standard Ultimately Make a Difference?

Addressing this question may involve reconsideration of some of the previous requirements. To some degree, the ultimate difference requirement is why the WG 5 symbols research has not been funded. If a symbol for differential lock is not absolutely the best alternative and therefore not understood the first time by a driver, what are the consequences? How do those consequences compare with the consequences of a poor choice for a recommended minimum-time headway for an adaptive cruise-control system?

14. Does the Standard Anticipate the Future?

Within TC 22/SC 13/WG 8, a period of at least 3 years is required to progress from a new work item to a standard. Topics can be preliminary work items for several years before formal work on a standard begins. All too often, immediate work programs tax the resources of experts leaving little opportunity to ponder long-term needs.

What Are the Risks with Telematics?

Given these considerations, what should be done to develop standards for driver interfaces for telematics? To determine where standards are needed (requirement 3), one must explore the risks of using telematics and the factors that affect usability. Promoting safety usually promotes usability. In terms of safety, telematics applications could:

1. be too visually demanding, distracting drivers from the road
2. be too cognitively demanding, interfering with drivers thinking about driving
3. require immediate attention, overriding driving

Each of these 3 points is discussed in the sections that follow.

1. Visual Demands

The relationship between visual demand and the number of expected crash involvements in North Carolina for a particular year has been quantified by Wierwille (1995). His work has been extended by this author to predict the number of deaths in the United States for any year (Green, 1999d). To put these estimates in context, the number of motor-vehicle-related injuries is about 100 times the number of deaths.

Number of deaths in U.S. in year x =

$$1.109 * (x - 1989) * (\text{market penetration fraction}) * \\ [-0.133 + [0.0447 * (\text{mean glance time})^{1.5} * (\# \text{ of glances}) * (\text{frequency of use/week})]]$$

where

x = year after 1989 (e.g., 2000)

market penetration fraction = fraction of vehicles on the road that have the feature

mean glance time = mean time (in seconds) the driver looks away from the road

of glances = number of times the driver looks away from the road to complete the task

frequency of use/week = number of times the task is completed per week.

Note that the product of mean glance time and the number of glances equals the eyes-off-the-road time.

Wierwille's work was very carefully done and many of the parameter estimates were based on multiple sources of information. Furthermore, the author has recomputed the regression estimates and found them to be in agreement with those offered by Wierwille. One potential item deserving further investigation is the power term from the mean glance time. In an

unpublished reanalysis of the Wierwille data, this author found that lower values (e.g., on the order of 1.2) slightly increased the percentage of variance accounted. Tsuda (1999) suggests squaring the mean glance duration.

The choice of the term is not merely an academic argument, but one that has significant impact for potential standards effort. If the power term is large, then there may be a need to measure both the number of glances to complete a task and their duration. If the power term is small, then counting glances and using a crude estimate of glance duration may be sufficient. Complicating the situation is a tendency for the mean duration of glances in a task to be shorter as the task time increases (Green, 1999d).

2. Cognitive Demands

For cognitive demand, what some have called “mind off the road” or “situation awareness” or “cognitive capture,” the appropriate measures and equations are less apparent. What constitutes not thinking about driving? Is it daydreaming, sleeping, paying attention to some other task (in part or in full), or is it something else? Many drivers have had the experience of being engaged in some difficult task such as entering a destination or paying attention to a phone call, and after having traveled a few miles, not remembering what they passed. There is the concern that while drivers may have performed some tasks reasonably well (e.g., maintained lane position), they may have unknowingly slowed down and because they were not fully engaged in the primary driving task, were much slower to react to an unexpected traffic hazard. In severe situations, drivers can be unaware that even primary task performance has degraded. For an untrained observer from afar, the weaving pattern of someone driving on expressway while engaged in a phone call resembles that of an intoxicated driver.

Although various methods (e.g., secondary task performance) have been proposed to identify interference, no fully satisfactory expression has emerged for cognitive demand on par with Wierwille’s approach for visual demand. Potentially, some information theory measure such as bandwidth could be appropriate (assuming the driver is a single channel processor). However, it is well known that performance is affected by the demands on short-term and long-term memory, so that a single channel assessment may be too simplistic. Much less is known about the cognitive demands of driving than the visual demands of driving, and much more work is needed to understand auditory demands to support efforts led by the French delegation.

Experience suggests that there is an extremely close coupling of cognitive and visual demands for visual tasks, especially tasks that involve reading in-vehicle displays and operating manual controls. It could be that in most situations those 2 demands are so closely coupled that examining visual demands alone is sufficient for most safety assessments. Equations or rules on par with Wierwille’s research to relate cognitive demands to crash risk would be very revealing, especially if they could identify where cognitive demands are independent of visual demands.

3. Requirements for Immediate Attention

The operation of conventional controls and displays such as the lights, radio, etc. is largely at the driver’s discretion, though there are a few situations where external demands may cause the driver

to honk the horn or flash their lights. These situations, however, are tightly coupled with real-time control of the vehicle and attention to the road.

In contrast, telematics tasks may not be so tightly coupled, and may interrupt driving as they can initiate requests for action. When a phone rings, people habitually answer it, sometimes regardless of the immediate driving situation. In Japan, the largest number of deaths related to cell-phone use are associated with answering the phone (Green, 2000). One could argue this is a stupid thing for drivers to do, but designers must recognize this is a foreseeable use, and products should be designed to minimize the associated risk.

Drivers will soon be receiving a growing number of messages, some related to traffic, but others related to nondriving activities (email messages of all types, pager messages with stock quotes and news alerts, etc.). All of these messages have some sense of urgency to them and drivers may attempt to deal with these messages immediately just as they do with incoming phone calls. A greater understanding is desired of how people will behave when these systems are in place.

Ease of Use/Usability

When systems are designed, the goal is not just to make them so they can be used, but so they are easy to use. Assessments of usability consider whether information can be readily seen or heard, if the information is understood given the user's knowledge, if decisions can be made quickly and without error, and if output can be produced with minimal effort. For systems or features that are not immediately comprehended, they should be easy to learn. There are entire books written on the subject of usability, and the author does not intend to summarize them here. Much of the efforts of TC 22/SC 13/WG 8 are directed towards usability. In many ways those efforts are headed in the right direction, so usability will receive less attention in this paper than was given to safety.

TC 22/SC 13/WG 8 Work Program

Given these safety and usability considerations, how is ISO TC 22/SC 13/WG 8 doing? The appraisal that follows is based on the author's attendance at a limited number of recent meetings and a review of the WG 8 email. The table that follows lists the work program including both active items and those that have been discussed within the last year.

Table 1. ISO TC 22/SC 13/WG 8 Work Program

Effort	Status
Dialog Management	DIS 15005
Auditory Information Presentation	DIS 15006
Measurement of Driver Visual Behavior	DIS 15007
Legibility (Visual Presentation of Information)	FDIS 15008
Message Priority	CD 16951
Suitability of TICS While Driving	DIS 17287
Visual Distraction of Info and Comm Systems	PWI
Safety Assurance	PWI
Principles of Warning and Caution	discussion
Comprehension of Visual Messages	discussion
ACC Human Factors (with TC 204/SC12/WG14)	DIS 15622
Collison Warnings (with TC 204/SC12/WG14)	discussion

CD = committee draft

FDIS = final draft international standard

DIS = draft international standard

PWI = preliminary work item

There are at least 6 perspectives from which the work program and information needs can be mapped onto each other: (1) human information processing of the driver (perception, attention, etc.), (2) systems and their characteristics (navigation, collision avoidance, etc.), (3) data versus process, (4) the global issue addressed (visual demand, ease of learning, etc.), (5) immediate versus long term needs, and (6) the safety issue addressed. By viewing the work program from these various perspectives, gaps and overlap become apparent. As an example, the figure that follows shows the program from a human information-processing perspective. Notice some lack of parallels, such as a procedure for measuring visual behavior but not one for auditory information and a preliminary work item for visual comprehension of messages but not one for auditory comprehension. Finally, notice the absence of any standards concerning output processes. In part, the gaps occur because of the primacy of visual information in driving.

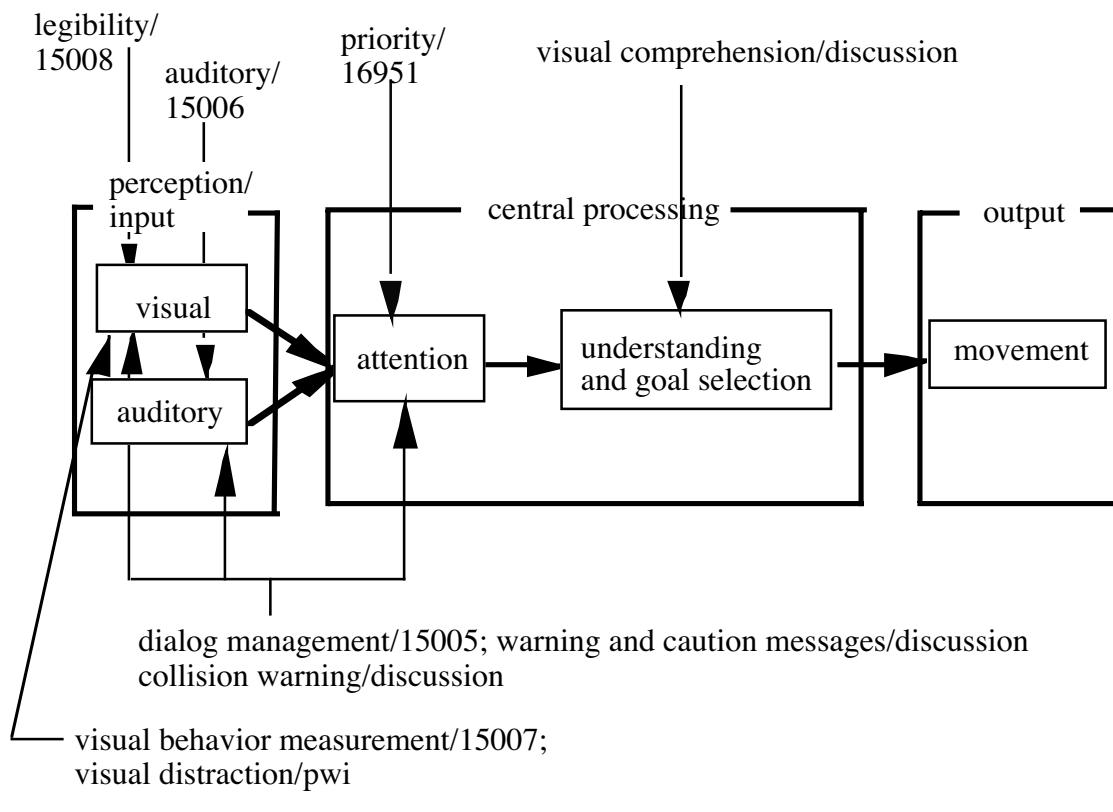


Figure 1. Information Processing Perspective of WG 8 Work Program

In terms of safety, there are 3 concerns: (1) excessive visual demand, (2) excessive cognitive demands, and (3) inappropriate interruptions.

1. Excessive visual demand

The matter of excessive visual demand is only now receiving attention within ISO. As has been mentioned earlier, excessive visual demand can be determined by measuring driver eyes-off-the-road time, a measure that is difficult to collect. (See requirement 11.) However, as several studies have shown (Green, 1999d; Nowakowski, Utsui, and Green, 2000), there is a good correlation between eyes-off-the-road time and task time, measured either statically or dynamically, hence making it a practical surrogate. For these and other reasons, the procedure outlined in SAE J2364 and the supporting method in J2365 have been offered as candidates for an ISO standard for navigation-system assessment. In a recent meeting in the United States by the ISO navigation task force, it was agreed that the standard should consider all TICS interfaces with manual controls and visual displays, not just navigation.

In parallel with the U.S. proposal, the German delegation has suggested an occlusion method to measure the number of glances required and the Japanese have suggested measuring maximum

glance duration. In the interests of international harmony, a phased approach has been suggested in which one or several of these assessments would be used. Test data are needed to identify which tasks will pass or fail all of these assessments, and which will pass or fail only some. The proposed assessments may be redundant and only a subset of the proposed approaches may be needed.

One of the strengths of the 15-second rule is that it not only provides a simple method for assessment, but that potential compliance can be determined by calculations (J2365). The German and Japanese proposals would be strengthened if analogous information was available. For the Japanese proposal, this information could take the form of extensive tables or histograms of glance durations for various tasks under various conditions, or methods for estimating glance durations. In the case of the German proposal, equations for calculating total glance time from task characteristics are desired, though tables of task times would also be useful. (See requirements 9 and 10.)

Finally, both the Japanese and German proposals could be strengthened by consideration of the crash predictions from Wierwille and further analysis by this author. These equations can provide a basis for determining acceptable levels of crash risk and for making the various proposals consistent in the level of risk accepted.

In the long term, the author does not believe that a strategy of just providing simple limits is best for the safety of drivers or the product interests of suppliers and manufacturers. A better approach is to develop workload managers, applications that determine the visual and cognitive demands of the driving task on a moment to moment basis, assess the drivers' performance capabilities, and then manage information flow to the driver. Thus, in heavy traffic on a winding road in bad weather when all the driver can do is drive, incoming cell-phone calls would be diverted to an answering machine. This concept was the central theme of the GIDS project (Michon, 1993), and is being explored as part of CeMVocAS (www.inrets.fr/ur/lescot/CeMVocAS/Pagedepa.htm). A key element to the development of workload managers is the construction of equations to predict the visual demand of driving based on road geometry, traffic, and other factors (Tsimhoni and Green, 1999; Tsimhoni, Yoo, and Green, 1999).

2. Excessive cognitive demands

At this point, there are no proposals to assess excessive cognitive demand. As was noted earlier, it could be that for most contemporary systems, the visual predominance of the information presented makes it likely that the overload will be either a direct visual overload or a cognitive overload coupled with excess visual demand. However, in the near term many auditorily based systems are being planned, and they have the potential of leading to a pure cognitive overload. Necessary standardization deserves some thought.

3. Inappropriate interruptions

To some extent, the issue of inappropriate interruptions is dealt with by the dialog management and priority standards, standards that identify the relative importance of messages and provide

other design advice. However, the documents do not provide a means to calculate when interruptions will be inappropriate, and could be more rigorous in indicating what not to do. This is because of gaps in the literature, not missed opportunities by the ISO Dialog Management Task Force. Maybe considering the interruption problem from this perspective will suggest new approaches.

Future Driver Interfaces

Today, the driver interface in the motor vehicles consists of (1) a speedometer/tachometer display, (2) simple auditory alerts, (3) a limited function, hand-held cellular phone, (4) some switches on stalks and in the center console, and (5) possibly a multifunction display in the center console with surrounding switches for a navigation system. Requirement 14 states that standards should anticipate future interface developments. In the future, there will be growth in the use of voice controls (including speech recognition, text to speech, and digitized speech) and windshield HUDs, the potential integration of PDAs and phones (especially those supporting Bluetooth (www.bluetooth.com)), and in the long term, interfaces with wearable computers. Driver interface standards need to be developed now to accommodate these devices so that when the technical and cost issues are resolved, standards development does not slow product introduction. Many of the requisite technologies will be in place within 3 years or less, but human interface standards for motor vehicles have not even been discussed, let alone completed within that time frame.

Specifically, both Microsoft (AutoPC) and Jaguar have products with speech recognition interfaces, and more products are expected in the future. As interfaces proliferate, the lack of a standardized command set could be a problem, though the consolidation of speech interface suppliers and limited OEM tailoring of interfaces will be a factor. Both research on and standards for command sets are desired.

Bluetooth-capable phones could become widespread very quickly. This would lead to a large increase in the amount of off-board information drivers will readily be able to access. Access to email and the web have the potential of overloading drivers. Some of these features are accessible now access via phones and will become much more common. Bluetooth chipsets are predicted to become inexpensive anywhere from 1 to 3 years from now (Ohr, 2000).

PDAs, most likely Palm machines, could become quite common in future vehicles now that some manufacturers have decided to provide cradles for them. While PDAs can be used to transfer data, their displays are quite small, so the amount of readable text that can be presented in a motor vehicle is limited. There has been no discussion of tailoring PDA displays for use while driving, though clearly the provisions of DIS 15008 are appropriate.

Although auditory navigation information by itself can be quite effective, there are many situations where also seeing a map is very useful. The need for easy-to-read maps may encourage manufacturers to develop large-area, full-graphic HUDS for navigation. However, once installed, some constraints on information presentation may be needed. There also have been proposals to allow drivers to watch broadcast TV on a HUD while driving, though in some

places it is legal. If a spreadsheet can be presented on a HUD to a driver while driving, someone will try to do it.

Many believe that cellular phones and PDAs will be replaced by wearable computers within 10 years. No one has considered how wearable computers might be integrated into motor vehicles and or what their implications may be for driver interfaces.

What Can Be Done?

The primary reason that TC 22/SC 13/WG 8 has not done more to develop telematics standards is that the number of experts is limited. However, the motor vehicle industry is changing and responsibility for design is shifting from the OEMs to the tier 1 suppliers, electronics suppliers, and others. It is important to recruit those companies, the computer manufacturers, the service suppliers, and the telephone companies to participate in ISO TC 22/SC 13 and TC 204/SC 12 activities. They could provide the needed experts though their familiarity with safety issues is limited. To support the exchange of information, especially with new contributors, greater use of the web (to track document progress, post versions, etc.) is encouraged. The electronics and computer companies are much more oriented toward exchanging information on the web than the automotive OEMs.

With adequate expertise, the research necessary to support standards development could be funded and appropriate standards developed. There are critical gaps in the existing work program with regard to auditory interfaces (to support the French efforts), design for safety and safety evaluation, workload-manager development, and future interfaces involving phones, HUDs, PDAs, and wearable computers. These gaps have appeared in spite of significant efforts from hard-working colleagues around the world. As hard as they try, they need more resources to continue their noteworthy progress as the demands on them increase.

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