NHTSA Driver Distraction Internet Forum

Summary & Proceedings

July 5 – August 11, 2000

Draft Report Submitted by

Westat
1650 Research Blvd.
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November 15, 2000

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipients's Catalog No.
4. Title and Subtitle NHTSA Driver Distraction Internet Forum: Summary and Proceedings		5. Report Date November 2000
		6. Performing Organization Code
7. Author(s) Robert E. Llaneras		8. Performing Organization Report No.
9. Performing Organization Name and Address Westat 1650 Research Blvd. Rockville, MD 20850		10. Work Unit No. (TRAIS)n code
		11. Contract of Grant No. DTNH22-99-D-07005
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, DC 20590		13. Type of Report and Period Covered Final Report, 3/30/2000-12/31/00
		14. Sponsoring Agency Code

15. Supplementary Notes
Contracting Officer's Technical Representative (COTR); Michael Perel.

16. Abstract
The National Highway Traffic Safety Administration (NHTSA) sponsored a virtual conference on the Internet (held July 5- August 11, 2000) to understand the risks from distraction associated with the explosive growth of in-car electronics. The Internet Forum provided an opportunity for technical experts and the public (both in the U.S. and internationally) to download research papers, ask questions, and share experiences regarding the use of in-vehicle devices (cell phones, navigation systems, wireless Internet, information & entertainment systems, night vision systems, etc.). Content on the site was organized into two basic areas: (1) Experience with technologies, and (2) Technical issues. The former provided opportunities for the driving public to share their experience with specific technologies in the context of driving and to provide their perspectives on basic issues related to their use. Discussions emphasized use of cell phones, navigation systems, night vision systems, wireless Internet, and information and entertainment systems. The "Technical Issues" section was devoted to general cross-cutting issues related to the safety impacts of in-vehicle technologies; five separate discussion areas were provided: Defining benefits and safety risks, Technical challenges associated with measuring distraction, Equipment design features and design solutions, Regulations, guidelines, and enforcement, and Safety campaigns and public education surrounding the safe use of in-vehicle technologies. In all, the site received over 23,000 hits with over 9,500 unique users and 2,500 registered guests. The site remains available as an information repository and can be accessed at www-nrd.nhtsa.dot.gov/driver-distraction/Welcome.htm.

17. Key Words	18. Distribution Statement
Driver Distraction In-Vehicle Technologies	Document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified	81	

Form DOT F1700.7 (8-72) **Reproduction of completed page authorized**

Acknowledgments

This Internet Forum would not have been possible or successful without the active participation of the many public citizens and those affiliated with industry, trade and professional societies and academic research organizations who invested in sharing their experiences and opinions regarding these technologies. We extend our sincere thanks and anticipate that the information provided will further our understanding of the issues surrounding the use of in-vehicle technologies. We are also indebted to the many individuals who so graciously served as moderators and expert panelists (these individuals are noted below). Finally, we would like to thank Jim McKelvey and Aimee Poling with MIRA Digital Publishing for their significant contributions in developing and hosting the web site.

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Charlie Garness (Va. Tech.)
Kenneth Gish, Ph.D. (Scientex Corp.)
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Thomas Ranney, Ph.D. (Transportation Research Center)
Aaron Steinfeld, Ph.D. (California PATH)
Eric Traube (Intelligent Transportation Society of America)

"Ask the Expert" Panelists

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David Curry, Ph.D. (Deilphi-Delco)
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EXECUTIVE SUMMARY

The Internet Forum provided an opportunity for technical experts and the public (both in the U.S. and internationally) to download research papers, ask questions, and share experiences regarding the use of in-vehicle devices. In all, the site received over 23,000 hits with over 9,500 unique users and 2,600 registered guests. Discussions emphasized use of cell phones, navigation systems, night vision systems, wireless Internet, and information and entertainment systems. General cross-cutting issues related to the safety impacts of in-vehicle technologies (benefits & risks, measuring distraction, equipment design features, regulations, guidelines and enforcement, safety and educational campaigns) were also discussed. Informal polls addressing a variety of issues were also used to stimulate discussion on key topics and provide a sense of the general feelings of Forum participants – results are not scientific and should not be interpreted as representatives of drivers in general. The site experienced significant growth within the first three weeks with the largest single period of growth occurring between weeks 2-3. Although the vast majority of registered guests (92%) were on-board by the end of the third week of the forum, sustained participation was observed throughout the conference including the last two weeks of the event. Almost three-quarters of the comments posted on the site (73%) were contributed by private citizens. Although experience with use of specific in-vehicle technologies varied, nearly 2 out of every 3 registered guests used cell phones in their vehicles.

Experience With In-Vehicle Technologies

Nearly half of the comments posted on the site (46%) related to cell phones. Comments reflected perspectives from drivers impacted by others using cell phones, as well as from technology users themselves describing their own experiences with operating cell phones while driving. According to poll results, the overwhelming majority of participants (75%) felt it was not safe to talk on a cell phone while driving; indeed 74% of the poll respondents felt local governments should enact laws to restrict the use of these devices while driving. Even a majority of experienced cell phone users agreed that some form of restriction or regulation governing cell phone use while driving was needed. Many also felt that hands-free technology is not sufficient to address the safety concerns while driving, arguing that the conversation itself (or cognitive distraction) contributes to the underlying problem. Some even felt that hands-free technology could exacerbate the problem by encouraging cell phone use while driving. Cell phone use while driving was perceived to contribute to traffic disruptions and conflicts; numerous accounts of near-misses and first-hand testimonies of cell phone-related crashes were posted on the Forum. Although it was recognized that poor driving performance is not limited to distraction induced by cell phones, many felt that steps to address this problem should be considered given the widespread use of this technology. There was considerable disagreement, however, on what particular actions or steps are needed in order to preserve the benefits of cell phones without causing unsafe driver distraction. Education and safety campaigns, better equipment designs, standards, requirements for hands-free devices, bans on cell phone use while driving, and enforcement of existing laws were among the solutions proposed to address the distraction probelm.

The distraction potential and safety impacts of in-vehicle navigation systems were also explored. In general, although in-vehicle navigation systems were perceived to have significant safety benefits, improperly designed or implemented systems were believed by many to potentially compromise safety. A number of key system design features and interface characteristics were discussed and perceived to impact the safety and utility of these systems. These include the location of displays and controls, content of the displays, interaction modes (voice versus text), and accessibility to certain functions and features while driving. Performing complex, multi-step

tasks that require significant visual demands, such as programming a destination, while driving were also viewed by many as a significant safety threat since they require drivers to look away from the road. Poll results suggest that a majority of drivers would purchase navigation systems even if the system prevented them from entering a destination when the vehicle is in motion. Calls for user-friendly designs (large, simple, straight forward and easily accessible controls; voice recognition systems; large, clearly visible displays, etc.) were voiced by many participants and were thought to alleviate or address many of the safety concerns with these systems. Few specific research recommendations were posted, although papers available on the site provide some guidance for needed research, including examining driver object and event detection when operating various route guidance and navigation systems, as well as the relative safety impacts of various design features (voice recognition and speech based systems).

Although night vision systems are intended to increase safety by enhancing drivers' ability to detect objects at night, some questioned their overall safety benefit fearing that the display itself could serve as a significant distraction or that drivers would negate any benefit by using the system to drive faster or riskier under poor visibility conditions. A substantial percentage of people (34%) were simply unsure of the safety benefit of night vision systems, and no objective scientific studies were available to support either viewpoint. Since night vision systems represent newly introduced technology, relatively little experience with the systems was reported on the Forum (less than 8% of registered users reported having experience with these systems). Much discussion centered on specific system design features such as the use of HUDs located low in the windshield which require drivers to match images on the display to those in the environment, and drivers' ability to learn to use the system properly.

Approximately 4% of comments posted on the Internet Forum were related to driver experiences and perceptions of wireless Internet devices. A majority of discussion focused on the need for e-mail access while driving, with opponents arguing that such devices are inherently dangerous and that those desiring more efficient use of commute time should take public transportation. Proponents maintained that safe designs using voice technology are possible and that as the technology advances drivers will need to adapt to it. Many suggested that listening to e-mails would be no different than listening to the radio, or that safety could be achieved through speech-based technology and/or interlocks which prevent drivers from accessing information when the vehicle is in motion. Others argued that answering e-mails while driving would lead to the same problems as answering cell phones, and that the use of these devices would impose greater workload levels than simply conversing with a passenger or even holding a cell phone conversation. Individual differences in driver age and experience, as well as differences in driving conditions were thought to affect drivers ability to interact with these systems.

Approximately 16% of comments posted on the Internet Forum addressed Information and Entertainment systems as well as "other" technological or non-technological in-vehicle distractions. Distraction associated with loud and obnoxious car stereo systems, in-vehicle televisions, billboards, mobile billboards, and children were among the items discussed. Surprisingly, large numbers of comments posted in these areas addressed the use of Daytime Running Lamps (DRLs). Nearly all were negative comments relating to the practice. DRLs were perceived to needlessly draw attention away from the road, reduce the conspicuity of emergency vehicles and motorcycles, contribute to glare and driver fatigue, and cause other drivers to adapt their behavior in manners that may not be safe. The main concern appeared to be with the use of excessively bright lights. Calls for limits in brightness as well as research to document the effect of DRLs on crashes and the visibility of emergency vehicles were made by many participants.

Cross-Cutting Technical Issues

Over one-quarter of the comments submitted during the 5-week conference explored cross-cutting technical issues. Discussions of the benefits and safety risks of in-vehicle technologies centered on cell-phone use while driving; however, some general perspectives regarding other forms of technology and distractions were also discussed. The conveniences afforded by these technologies were perceived by many not to be justified given the risks they bring; others argued that the benefits could be realized through judicious use and better designs. Although several papers available on the site assessed the risks and benefits associated with use cell phones, it was evident that benefits and safety risks of technology use while driving are largely unknown.

Forty-five comments, accounting for 6% of the total, addressed issues associated with methods and techniques for measuring distraction, and a number of techniques to assess the safety problem were advanced and discussed. It was argued that the “best” measures for measuring distraction are those which are theory driven, reliable, objective, and generalizable. A number of surrogate crash safety measures and techniques for assessing distraction were outlined, including near misses, event and obstacle avoidance measures, lane maintenance and eye-glance measures. Some commented that the safety impact of various in-vehicle technologies can and should be evaluated based on comparisons to generally accepted non-technology tasks, arguing that societal accepted tasks performed while driving (e.g., tuning a radio) can serve as appropriate baselines. Work to develop practical, reliable and meaningful metrics to measure demands imposed by in-vehicle systems, models for use in evaluating in-vehicle systems, and integrated attention monitoring devices were outlined.

Consumers appear to want and demand in-vehicle devices that are easy and safe to operate. Approximately 80% of respondents indicated that design and ease of use was an important consideration when selecting and purchasing an in-vehicle device. A variety of equipment designs features were discussed, including radio control designs, integration of ITS devices, Head-Up Displays (HUDs), in-vehicle e-mail system designs, and countermeasures. Technology-related features perceived to enhance safety included hands-free devices, safety interlocks which allow drivers to operate devices only when the vehicle is stopped or in park, in-dash cell phones that automatically mute the radio as well as answer incoming calls, and Head-Up Displays that allow drivers to access visual information quickly. Use of speech-based and voice recognition technologies were hotly debated during the Forum and were the subject of a number of papers available on the site.

The issue of regulation was one of the most hotly debated topics discussed on the Internet Forum. Many argued that the only effective way to increase safety is to ban or severely restrict use of “dangerous” in-vehicle technologies and activities that have been demonstrated to be hazardous. Opponents argued that regulation was not an effective alternative (laws already exist governing driver behavior, bans or restrictions are not effective at regulating behavior, etc.). Many perceived bans on technology to be impractical, and suggested restrictions in the use of the technology or changes in design (e.g., hands-free devices, interlocks, etc.) would be more effective. Nearly all believed that passengers should have full unrestricted use of in-vehicle technologies and not be precluded from using available technology – the problem is driver-centered. Limited discussions addressing guidelines for the design and evaluation of technology took place on the Internet Forum, however, several papers outlining and critiquing existing practices and guidance were posted on the site.

The need for educating drivers on the responsible and safe of use in-vehicle technologies such as cell phones was clear. Many believe that public education and training about the safety use of in-vehicle technologies would increase safety, and some participants relayed personal testimonies of how their behavior was changed as a result of education, safety tips and personal experience with using the devices. Discussions suggest that safety campaigns and education on technology use can be effective, although reliance on this alone is not likely to address all of the safety concerns with in-vehicle technologies.

INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) sponsored a virtual conference on the Internet (held July 5- August 11, 2000) to understand the risks from distraction associated with the explosive growth of in-car electronics. The Internet Forum provided an opportunity for technical experts and the public (both in the U.S. and internationally) to download research papers, ask questions, and share experiences regarding the use of in-vehicle devices (cell phones, navigation systems, wireless Internet, information & entertainment systems, night vision systems, etc.). Westat designed the site and managed the five week conference, which was launched July 5, 2000 and officially ended August 11, 2000. The site received national media exposure on USA Today and CNN following a NHSTA Public meeting held in July. In all, the site received over 23,000 hits with over 9,500 unique users and 2,500 registered guests. The site remains available as an information repository and can be accessed at www-nrd.nhtsa.dot.gov/driver-distraction/Welcome.htm.

Web Site Design & Content

The site provided access to a number of features, including technical papers, links to other resources and web sites related to driver distraction and safety, message boards for discussion and comments focused on issues and papers, informal polls to stimulate discussion and frame issues, as well as opportunities for Q&A with a panel of knowledgeable experts in the field. Although registration was optional, only registered guests were provided full access to many of these features (see Figure 1). All site visitors (registered or unregistered) were able to read and/or download technical papers, access related site links and resources, and view posted comments and expert opinions posted in response to submitted questions.

Figure 1. Internet Forum Site Features. Only Registered Guests were Allowed to Post Comments, Respond to Polling Items, and Pose Questions to Expert Panelists.

Content on the site was organized into two basic areas: (1) Experience with technologies, and (2) Technical issues. The former provided opportunities for the driving public to share their experience with specific technologies in the context of driving and to provide their perspectives on basic issues related to their use. Discussions emphasized use of cell phones, navigation systems, night vision systems, wireless Internet, and information and entertainment systems. The "Technical Issues" section was devoted to general cross-cutting issues related to the safety impacts of in-vehicle technologies; five separate discussion areas were provided:

- Defining benefits and safety risks,

- Technical challenges associated with measuring distraction,
- Equipment design features and design solutions,
- Regulations, guidelines, and enforcement, and
- Safety campaigns and public education surrounding the safe use of in-vehicle technologies.

Twenty-four papers addressing a variety of in-vehicle technologies and cross-cutting issues were available on the site (See Appendix A for a list and summary of the papers).

Site Statistics

Hits & Registered Guests

Over the course of the five-week conference, over 9,500 unique visitors logged onto the site; approximately 2,600 individuals registered, enabling them to post comments, answer polling items, and submit questions to the expert panel. Figure 2 depicts some basic statistics gauging site use over the conference period and plots the cumulative number of hits, unique users and registered guests. The site experienced significant growth within the first three weeks, with the largest single period of growth occurring between weeks 2-3. Large increases in access typically followed media exposure and events (CNN broadcast, NHTSA Public Hearing, etc.). Although the vast majority of registered guests (92%) were on-board by the end of the third week of the forum, sustained participation was observed throughout the conference including the last 2 weeks of the event. In all, the site received almost 24,000 hits yielding a total of 700 comments posted. The vast majority of comments were posted by private citizens and related to cellular telephone use.

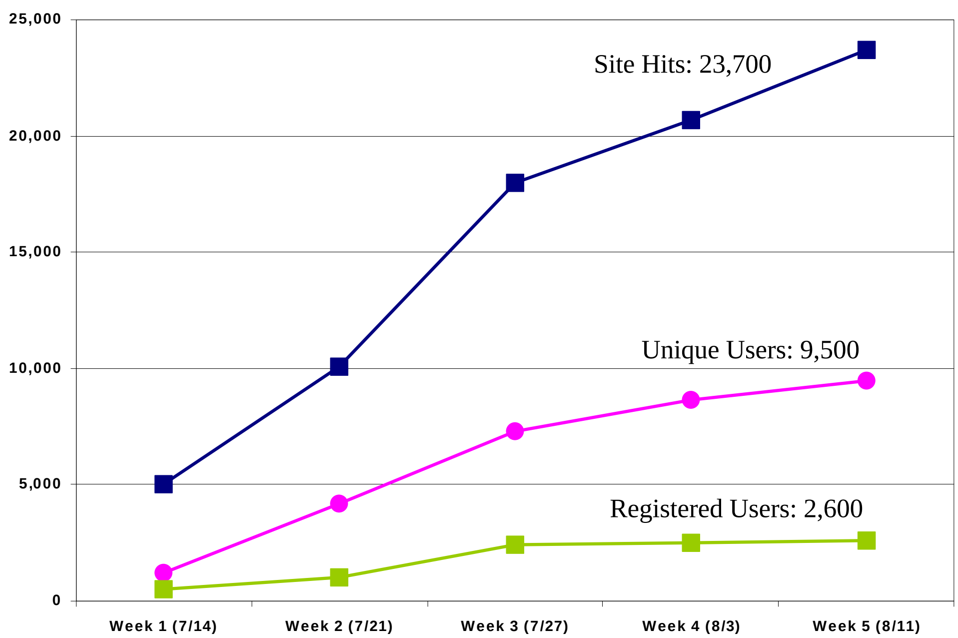

Figure 2. Internet Forum, Cumulative Number of Hits, Unique Users and Registered Guests Across Weeks

<u>Registered Guests</u>

As part of the registration process, registered guests provided information characterizing their affiliation. As shown in Figure 3 which breaks-out the percentage of registered guests by affiliation, the majority of forum participants (64%) were private citizens. The next single largest affiliation category, "other" provided no specific information regarding affiliation. Approximately 20% comprised individuals from government, academia/research firms, industry/trade associations, and automotive OEM/suppliers; the proportion of registered users were approximately equivalent across government, academia/research firm, and OEM/Suppliers. Relatively few individuals from law enforcement and judicial agencies were represented.

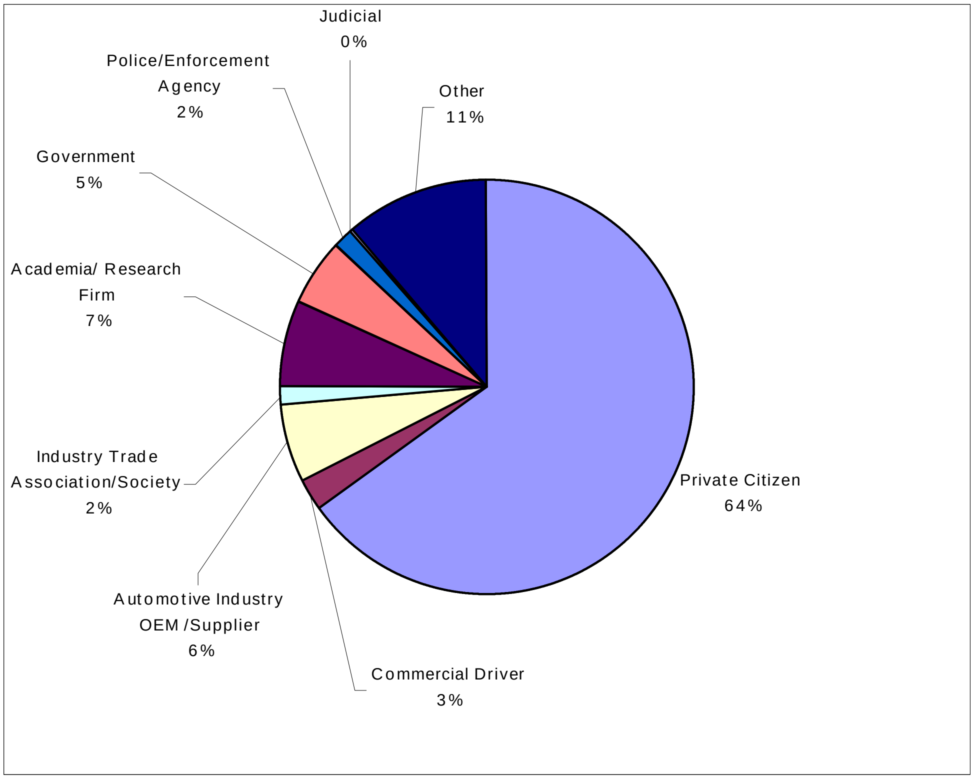

Figure 3. Self-Reported Affiliation of Registered Guests.

Almost three-quarters of the comments posted on the site (73%) were contributed by private citizens. Representatives from the automotive industry, government and academia/research organizations contributed equally with approximately 100 comments, accounting for about 14% of all posted comments.

Registrant Self-Reported Experience With Technology

Registrants indicated their experience with using various technologies in their vehicles. Figure 4 illustrates the pattern of technology use by registered Internet Forum participants. The most used technologies included cellular phones, pagers and navigation systems. By far, cellular telephones were the most prevalent technology used by respondents; nearly 2 out of every 3 registered guests used cell phones in their vehicles. The shear volume of comments relating to cellular telephone use while driving also reflects the widespread use and availability of this technology. The second most prevalent technology used by registrants was the pager, followed by navigation systems, 29% and 18% respectively. Despite recent findings indicating their widespread use, relatively few guests reported experience using e-mail and wireless Internet technologies; between 5-6% of the registrants reported using these two technologies in their vehicles. Head-Up Displays (HUD's) and night vision systems were the least used technologies, and most likely reflects limited availability of these systems.

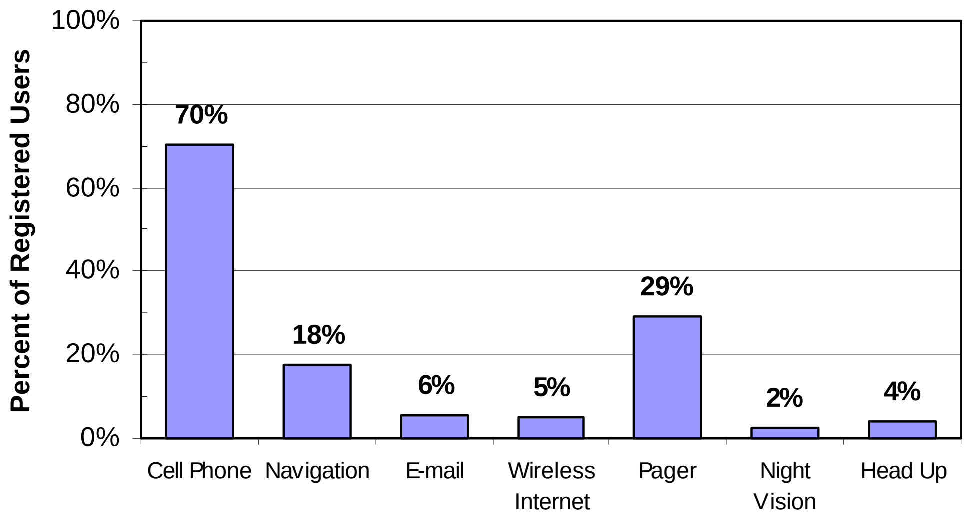

Figure 4. Proportion of Registrants Reporting Using Technologies in Their Vehicles

EXPERIENCE WITH IN-VEHICLE TECHNOLOGIES

Almost three-quarters of the comments received related to driver experiences and perceptions regarding specific in-vehicle technologies: cell phones, navigation systems, night vision systems, wireless Internet, information and entertainment systems, etc. The remaining 26% addressed technical issues such as benefits & safety risks, measuring distraction, and design features. The sections below summarize discussions and highlight key points associated with the use of each of the profiled technologies. Results of informal polls addressing a variety of issues are reported below. It is important to understand that these polls were used to stimulate discussion on key topics and provide a sense of the general feelings of Forum participants – results are not scientific and should not be interpreted as representatives of drivers in general (See Appendix A for a complete list of polling item results). Moderators were used to periodically synthesized comments, keep discussions focused and moving, emphasize key points, and offer additional insights into related issues.

Cell Phones

Nearly half of the comments posted on the site (46%) related to cell phones; in all, over 300 comments on this topic were posted. Comments generally addressed one or more of the following issues: perceptions of driving related problems associated with cell phone use, views on the safety impacts of cell phone use, personal testimonies relaying typical crash or near-crash scenarios, proposed solutions. Many comments reflected perspectives from drivers impacted by others using cell phones, while others originated from technology users themselves describing their own experiences with operating cell phones while driving. Of the 24 papers available on the site, six were devoted to issues directly related to cell phone use while driving. Several papers represented major literature reviews in the area summarizing known research evidence regarding the impact of cellular phone use while driving and safety. Although no consensus was generally observed, considerable debate among participants took place and a number of viewpoints and perspectives were gathered from forum participants.

Perceived Safety

According to poll results, the overwhelming majority of participants (75%) felt it was not safe to talk on a cell phone while driving; indeed 74% of the poll respondents felt local governments should enact laws to restrict the use of these devices while driving. Nevertheless, some respondents (29%) believed it was safe to use a cell phone under open road, light traffic conditions, and a minority (7%) believed it safe to use anytime while driving. Holding a conversation, doing cell-phone related tasks (e.g. jotting down notes), and dialing a telephone number were among the biggest safety concerns. Interestingly, answering the telephone was not perceived to be a large

"Conversing on a cell phone while driving, whether hands-free or not, is a significant distraction from the task at hand, driving the car."

- Private Citizen

"In my opinion it is the abstracted mental state that causes the risk rather than any physical manipulation of the cell phone itself"

- Private Citizen

"I will have traveled 10 or even 20 miles while gabbing and, at the conclusion of the call, have zero recollection of how I got from Point A to Point B."

- Private Citizen

"Sometimes I'd pull out in front of another car while paying attention to the conversation, and other times, I'd space out on what the person was saying to me while I tried to avoid hitting a pedestrian."

- Private Citizen

concern relative to these other activities, although data in Japan suggest that answering the telephone is the leading contributor to cell-phone related crashes in Japan (presumably because drivers have no control over when the phone rings, are under time-pressure to answer the phone, and sometimes have difficulty accessing the phone itself). These results were also consistent with the majority viewpoint that hands-free technology is not sufficient to address the safety concerns while driving. Some voiced concern that widespread use of hands-free cellular phones would actually make the problem worse by encouraging cell phone use. Even though hands-free (and voice recognition) technology may eliminate the associated manual and visual demands of operating a cell phone, allowing drivers to keep both hands on the wheel and eyes on the road, these technologies do not address the more insidious and potentially problematic issue of cognitive distraction. As indicated by one expert panelist, "Several studies suggest that the primary distraction associated with cellular telephone is the conversation and not the dialing" (John Lee, 7/21/00). This perspective was supported by numerous accounts of cell phone users who report a loss of situational awareness and concentration when conversing on a cell phone while driving. Several participants admitted being distracted during conversations - some even stopped using the cell phone, or severely restricted their use, after realizing it is not safe to talk on the phone while driving. These types of changes in behavior were usually a result of near-crash experiences. One participant felt that access to a cell phone while driving actually improved their driving performance by enabling them to contact clients when running late for appointments avoiding the need to drive unsafely (speed) or feel rushed.

<u>Relationship to Driving Performance & Crashes</u>

Although poor driving performance is not limited to distraction induced by cell phones, a number of driving performance problems were commonly attributed to cell phone users. Referenced driving behaviors exhibited by cell phone users included, among others, poor speed maintenance (slow or inconsistent speeds), poor lane control (weaving), erratic maneuvers (sudden stops, abrupt lane changes, cutting-off others), and slow starts at signalized intersections. These behaviors were perceived to contribute to traffic disruptions and conflicts. Drivers using cell phones while driving were also perceived by some participants as dangerous, oblivious to traffic and driving conditions, and unable to respond to traffic events quickly and safely. Effects of cell phone use while driving were even compared to driving under the influence of alcohol. A number of accounts were provided in which drivers were forced to compensate for the mistakes of cell-phone drivers in order to avoid a collision. Professional drivers commented that they routinely experienced near-misses with a distracted cell phone user – some averaging as many as 2-3 per week. First-hand testimonials provided by individuals involved in cell phone-related crashes included the following typical crash scenarios (Driver is dialing or conversing on a cell phone and):

> *"Although cell phones are not the only distraction that cause poor driving performance, they may be the most serious"*
> *- Private Citizen*

- Rear-ends a vehicle stopped at a traffic light or stop sign (or in a traffic queue). Often, no attempt to brake is made by the driver.
- Runs a stop sign or traffic signal and side-swipes a vehicle.
- Turns into traffic from a driveway or parking lot (without recognizing the presence of cross-traffic) and is struck.
- Stops at a stop sign or intersection, pulls into traffic and is struck or hits a pedestrian.

Approximately 80% of poll respondents indicate having witnessed or experienced a crash or close call resulting from a driver using a cellular phone. A similar percentage (79%) report experiencing or witnessing a crash or close call resulting from a driver being distracted by something *other* than a cell phone (e.g., reading a map, eating, personal grooming, etc.). A number of papers available on the site attempt to draw relationships between cell phone use and crashes, vehicle control, and driver situational awareness.

Proposed Solutions & Research Needs

Almost all participants recognized that certain types of driving behaviors (weaving, slowing, etc.) are unsafe and that distraction caused by cell phones (or other events, activities or devices) can evoke this type of driving. There was considerable disagreement, however, on what particular actions or steps are needed in order to preserve the benefits of cell phones without causing unsafe driver distraction. A variety of solutions were proposed to address potential problems associated with cell phone use or misuse while driving. The nature of the proposed solution varied based on the perceived cause and magnitude of the problem (e.g., design of the technology, ability of the driver to multi-task, safety impacts of behavior, etc.). Regulatory solutions (bans, restrictions, requirements, etc.) were hotly debated with extreme viewpoints encompassing concerns over individual rights and personal responsibilities and freedoms, while others advocated the need for public safety. Proponents in favor of regulation maintained that public safety is the basic issue and that while some cell phone users can act responsibly, others represent serious threats to safety on our roads. In their view, the threat to public safety is obvious and laws are needed to safeguard all citizens; a driver's "right" to use their cell phone while driving must not jeopardize others' right to safety. Opponents to regulation argued that existing laws are sufficient to address distraction in any form (including cell-phone use) and no new laws are necessary. What is needed is enforcement of existing laws to address careless or reckless driving. Many also felt that laws are not effective in regulating personal behavior, and questioned the government's role in this area (many were concerned that personal freedoms would be violated through such "over-regulation"). Yet others perceived the problem to be due to poor and irresponsible drivers (who cannot exercise good judgment about when its safe to use cell phones) and not the technology itself. This was consistent with poll results, where 65% of respondents believe that drivers do a poor job about making decisions about when it is safe to use technology while driving.

"We need to identify the key hazards of cell phone use in cars and find practical ways to mitigate them. Technologies and products exist to accomplish all of the above [make phones safer] with the phones that we use today…. Are we [consumers] willing to spend some money to reduce the extent of this problem?"
- Automotive Industry

"The solution is for consumers to demand driver-friendly technology."
- Private Citizen

"Through education, we can reinforce the driver's responsibility to safety. As an industry, we know that we have a responsibility to educate wireless customers on the responsible use of our products and services."
- Industry Trade Assoc./Society

"Drivers should be trained in certain principles and limitations of using cell phones while driving."
- Private Citizen

"Maybe cars should be designed to drive themselves."
- Private Citizen

"Some drivers can manage more than one task. It's not so much the driving skill as it is the management skill."
- Private Citizen

"The more technology advances the more each person will have to choose how much he or she is capable of handling. The ones that choose poorly and cause damage should be held accountable for their actions."
- Private Citizen

"It's not using the cell phone that's the problem. It's people not knowing their limitations and not using common sense while driving."
- Private Citizen

Suggested solutions included:

- Education and safety campaigns,
- Better equipment designs
- Standards
- Lock out features that restrict use of cell phone when the vehicle is in motion
- Requirements for hands-free devices
- Better training and licensing
- Enforcement of existing laws governing
- Automated Highway – “driverless” cars

Navigation Systems

Although the availability and use of in-vehicle navigation systems in the U.S. is currently limited (very few passenger car models offer such devices), a majority of the driving public is aware of such technologies, and the number of vehicles offering navigation systems is expected to increase dramatically. In Japan, many new cars sold come equipped with a route guidance and navigation system, and the infrastructure also exists to integrate real-time traffic information as part of these systems further expanding their utility. According to a J.D. Power and Associates survey of consumers who recently purchased or leased vehicles with a factory installed navigation system, consumers are generally very satisfied with these devices, and tend to use them to find the shortest routes to specific destinations as well as to locate restaurants, retail stores, and residential addresses.

Discussion on the Internet Forum centered around the distraction potential and safety impacts of in-vehicle navigation systems as well as experiences with specific systems (designs an functions). In general, although in-vehicle navigation systems were perceived to have significant safety benefits, improperly designed or implemented systems were believed by many to potentially compromise safety. A number of key system design features and interface characteristics were discussed and perceived to impact the safety and utility of these systems. These include the location of displays and controls, content of the displays, interaction modes (voice versus text), and accessibility to certain functions and features while driving. One frequently discussed design feature was the ability to view maps while driving. According to poll results, the ability to view maps while driving was not seen as a particularly important feature by 40% of respondents (provided that turn-by-turn directions were provided). Although comments addressing this issue suggest that this activity is a significant safety concern, a significant proportion of respondents (over 20%) perceived the ability to view maps while driving as very or somewhat important. Some argued that viewing maps on a display is as safe or safer than the commonly performed task of viewing paper-based maps while driving. Map complexity and the location of the display relative to the drivers' line of sight were two factors thought to impact the safety of this task and the system. Interestingly, only about one-third of all respondents believe it is possible to design electronic maps that can be safely used while driving (not surprisingly, over 60% of respondents affiliated with the automotive industry felt safe designs were possible). As with map reading,

"I've used a number of navigation systems in my work as an automotive journalist, and few are user-friendly enough to program quickly, much less operate while on the road. "
- Private Citizen

"A navigation system which requires the driver to take his eyes off the road to view a moving map on an in-dash display is obviously a driver distraction".
- Private Citizen

"A map display is useful in assuring the driver that they are where they intend to be, haven't gone too far or missed a turn. Something that a quick glance can tell you, similar to the time it takes to read a billboard."
- Auto Industry

"When properly set up, these systems can be very beneficial without causing a driver to be overly distracted."
- Private Citizen

"How safe is it to fumble around with folding and reading a paper map? Navigation systems will make certain aspects of driving more safe at the cost of increasing risk in other areas."
- Private Citizen

"Lost drivers are dangerous drivers. There are undoubtedly many other scenarios for accidents that could be prevented with the aid of navigation systems."
- Auto Industry

"I think it is dangerous to allow data input by the driver while driving. Unless the destination can be selected by Voice Recognition from a previously prepared address book."
- Private Citizen

performing complex, multi-step tasks that require significant visual demands, such as programming a destination, while driving were also viewed by many as a significant safety threat since they require drivers to look away from the road. While some systems automatically lock-out certain complex functions (e.g., destination entry) when the vehicle is in motion, others do not. Research addressing the task of destination entry while driving (available on the site) suggests that voice recognition technology may be safer than conventional visual-manual input modes. Poll results suggest that a majority of drivers would purchase navigation systems even if the system prevented them from entering a destination when the vehicle is in motion.

Proposed Solutions and Research

Calls for user-friendly designs (large, simple, straight forward and easily accessible controls; voice recognition systems; large, clearly visible displays, etc.) were voiced by many participants and were thought to alleviate or address many of the safety concerns with these systems. In general, systems that were mounted within the drivers' line of site (screens that pop-up from the top of the dashboard, or Head-Up Displays) appeared to be preferred to those mounted low on the dash or in the cockpit. One comment posted on the site relaying a navigation-related fatality attributed the incident to a poorly located unit installed in a rental car which caused the driver to run a red light; the navigation system was mounted down and to the right of the driver, requiring the driver to glance away from the forward road scene. Some found problems with integrated systems (those bundled with other vehicle systems - HVAC, radio, etc.) as they tended to use complex multifunction controls and overly complicated layers of menus (this criticism about integration is not necessarily leveled against "integration" itself as much as poorly integrated systems). Few specific research recommendations were posted, although papers available on the site provide some guidance for needed research. As with the cell-phone discussions, the concept of developing "driverless" cars (i.e. automated highways) surfaced as a long-term solution to the driver distraction problem. Suggestions to expand work conducted by the Society of Automotive Engineers to limit the total task time for the presentation of visual information and the manual control inputs associated with navigation functions accessible by the driver while the vehicle is in motion was also referenced. Several papers identified the need to examine driver object and event detection when operating various route guidance and navigation systems, as well as the relative safety impacts of various design features (voice recognition and speech based systems).

Night Vision Systems

The same advanced technology that U.S. forces used to carry out their missions under the cover of darkness in Operation Desert Storm is now available to automotive consumers. Night vision systems are intended to augment the driver's view out the windshield enabling nighttime drivers to detect potentially dangerous objects or situations existing well beyond the range of headlamp visibility. GM is the first automaker to offer consumers this feature (available on 2000 Cadillac Deville models) which creates infrared images based on heat energy emitted by objects in the viewed scene and projects them onto a Head-Up Display. Such systems could significantly reduce dangers associated with night driving, when over 25% of all crashes occur.

Although night vision systems are intended to increase safety by enhancing drivers ability to detect objects at night, some questioned their overall safety benefit, fearing that the display itself could serve as a significant distraction or that drivers would negate any benefit by using the system to drive faster or riskier under poor visibility conditions. Some concern was also mentioned about drivers "out-driving" their headlights. When asked if night vision systems would improve safety or pose a threat to safety by distracting drivers, 38% felt that a night vision system would increase safety. Nevertheless approximately 23% of respondents believe such systems would decrease safety. Representatives of government and the automotive industry were among the most optimistic, with 57 and 50 percent, respectively, holding to the view that these systems will increase safety on our highways. The research community was the only group having a higher proportion of respondents suggesting that these systems would decrease safety. A substantial percentage of people (34%) were simply unsure of the safety benefit of night vision systems, and no objective scientific studies were available to support either viewpoint. Since night vision systems represent newly introduced technology, relatively little experience with the systems was reported on the Forum (less than 8% of registered users reported having experience with these systems). Much discussion centered on specific system design features such as the use of HUDs located low in the windshield which require drivers to match images on the display to those in the environment, and drivers' ability to learn to use the system properly. One individual involved with the development of the system indicated that their experience suggests that drivers

"A Head Up device would be extremely practical for people who do lots of night driving."
- *Private Citizen*

"Night vision devices could give drivers false confidence. Drivers using them would be willing to drive in fog, rain or dust storms much faster than other drivers, thinking they are safe."
- *Private Citizen*

"Don't prevent me from getting one because irresponsible people that should not even be driving won't be able to handle a sensible safety feature."
- *Private Citizen*

"In a typical urban/suburban environment I found it more of a distraction than an aid. I found my eyes continually jumping between the HUD and the true driving scene trying to match the two types of information."
- *Automotive Industry*

"The HUD is not meant to be stared at, it is there for your peripheral vision to detect movement."
- *Automotive Industry*

become accustomed to the HUD within 30 minutes. Others suggested that “Just-in-Time Learning” could be used to educate consumers on the use of these and other advanced in-vehicle systems.

Wireless Internet

Wireless service providers are marketing new features that will allow customers to send and receive text messages on their mobile telephones, and the extension of the "wireless web" to hand-held devices such as phones and organizers is one of the hottest growth areas in the industry. A recent NHTSA survey found that 7% of drivers already have e-mail access in their vehicles and the use of these systems is expected to increase. Approximately 4% of comments posted on the Internet Forum were related to driver experiences and perceptions of wireless Internet devices. A majority of discussion focused on the need for e-mail access while driving, with opponents arguing that such devices are inherently dangerous and that those desiring more efficient commutes should take public transportation. Proponents maintained that safe designs using voice technology are possible and that as the technology advances drivers will need to adapt to it. When asked if it is possible to design wireless Internet devices that can be safely used while driving, the vast majority of respondents (65%) felt that safe designs are not possible. As illustrated in Figure 5, perspectives on this issue varied based on affiliation. Almost 50% of those affiliated with the automotive industry indicated that safe designs were possible. This viewpoint was affirmed by numerous comments on the site suggesting that listening to e-mails would be no different that listening to the radio, or that safety could be achieved through speech-based technology and/or interlocks which prevent drivers from accessing information when the vehicle is in motion. Overall, however, fewer than 20% of respondents indicated that safe designs for use

"Just because technology is available does not mean that it is appropriate to use it anywhere and everywhere! Permitting drivers to play with e-mail is dangerous, unsafe and plain stupid. "
- Private Citizen

"I think voice e-mail (listening to or speaking to create one) can be safe for the driver to perform while driving."
- Private Citizen

"Make a device in the car so that when a fax or e-mail comes in, the driver cannot open or read it until the car has come to a full stop."
- Private Citizen

"We just need to learn to use this technology and adapt to it. Just like fire, it can burn you, but if you learn to use it properly, it can improve the quality of your life."
- Private Citizen

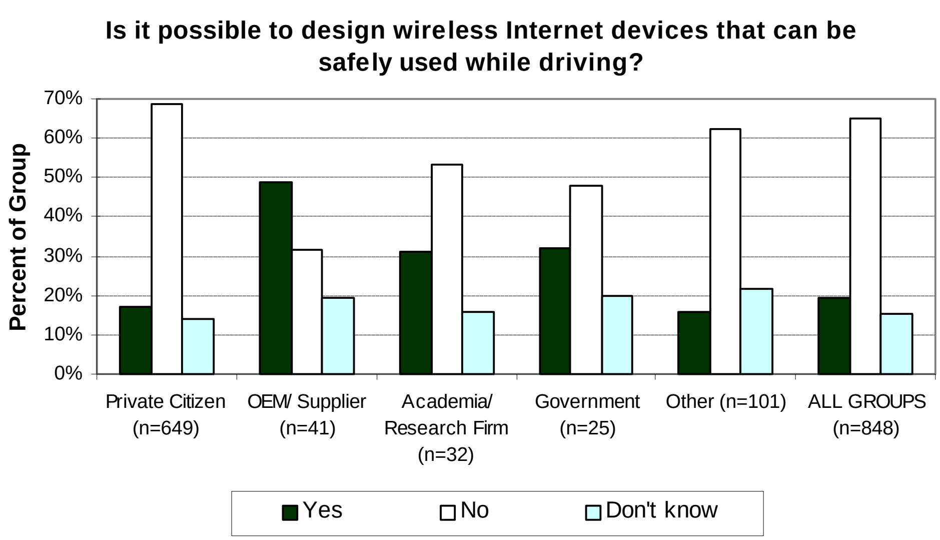

Figure 5. Polling Results Addressing Extent to Which Safe Wireless Internet Device Designs Are Possible. Responses Are Broken Out By Respondednt Affiliation.

while driving were possible. Some perceived that answering e-mails while driving would lead to the same problems as answering cell phones, others suggested that the use of these devices (which would require interacting with an automated voice system) would impose greater workload levels than simply conversing with a passenger or even holding a cell phone conversation. Objective research available on the site, suggests that the availability of e-mail while driving may indeed have a large effect on perceived workload and distraction, and a more limited effect on driving performance (Lee et al., 2000). While drivers can generally recognize the cognitive load imposed by the use of speech-based e-mail systems, the question of how well this corresponds to the actual level of distraction remains to be explored. Individual differences in driver age and experience, as well as differences in driving conditions may also affect drivers ability to interact with these systems.

Information & Entertainment

Approximately 3% of comments posted on the Internet Forum addressed Information and Entertainment systems; of these, almost half were devoted to distraction associated with loud and obnoxious car stereo systems. Many complained about the excessive noise produced by retrofitted stereo systems which were viewed as distractions not only to the driver of the equipped vehicle but to others in the vicinity who are forced to endure (and sometimes feel) the noise. Some reported witnessing incidents of rage directed at drivers of vehicles with these sound systems, others were concerned that important information and warnings (such as emergency vehicle sirens, car horns, bicycle bells, etc.) would be masked by the noise produced from these stereos. Impassioned calls were made to impose wattage and/or noise level restrictions, limit the number of speakers and the power of amplifiers, and ban sub-woofers and installation of additional batteries to power these systems. Although evidence linking distraction induced by loud stereos or "boom cars" and crashes are lacking, it is clear that these systems are a concern to many citizens. Another entertainment system discussed here was the use of in-vehicle televisions. The concern was not necessarily with the use of TV's by passengers, but by drivers themselves. Several reported witnessing drivers viewing dash-mounted TV sets or display screens while actively driving and negotiating their vehicles through traffic. This type of behavior was seen as an obviously safety threat and violates the Consumer Electronic Association statement pertaining to the use of video displays that are visible to the driver which states that, "…if a video monitor is used for television reception or video or DVD play, the LCD panel or video monitor should be installed so that these features will only function when the parking brake is applied."

> *"By far the most prevalent and most major distraction in cars today is sound systems, both OEM and aftermarket."*
> \- *Private Citizen*
>
> *"Put a TV set in a vehicle and the driver WILL try to watch it."*
> \- *Private Citizen*
>
> *"There should be stiff penalties (i.e., loss of driving privileges, big fines) for drivers who have a TV mounted in the front."*
> \- *Private Citizen*
>
> *"Anything that causes drivers to divert their attention from the serious and potentially dangerous business of driving is bad."*
> \- *Private Citizen*

Other

This final category was meant to capture "other" perceived technological or non-technological in-vehicle distractions, and generated a large number of comments - second only to the cell phones page (92 postings representing 13% of the overall submissions). Surprisingly, 45% of the comments posted in this category addressed the use of Daytime Running Lamps (DRLs). Nearly all were negative comments relating to the practice. Some felt DRLs were "the worst hazard on the road," or "perhaps the most distracting element on the road today," or "the most abhorrent obstacle to driving safety." Unlike many of the other technological devices discussed in the Forum, the distraction attributed to DRLs is unique in that it was perceived to induce distraction to *other* motorists and not to the equipped vehicle's driver. DRLs were perceived to needlessly draw

> *"The benefits of Daytime Running Lights are questionable, the hazards are clear. It's time for DRLs to be eliminated."*
> \- *Private Citizen*
>
> *"Often I turned down the rear view mirror because the lights behind me [DRLs]were so bright they were extremely annoying. How does this make driving any safer?*
> \- *Private Citizen*

attention away from the road to equipped vehicles, reduce the conspicuity of emergency vehicles and motorcycles, contribute to glare and driver fatigue, and cause other drivers to adapt their behavior in manners that may not be safe. The main concern appeared to be with the use of excessively bright lights. Some participants were under the false impression that NHTSA mandated the use of these innovations, contributing to their widespread use. A number of participants called for limits in brightness as well as research to document the effect of DRLs on crashes and the visibility of emergency vehicles.

Other issues and forms of distraction mentioned and discussed here included the following:

- Billboards, mobile billboards, “autowraps” and other advertising (outdoor electronic advertising)
- Children as distractions
- Driver training and licensing requirements
- Problems with young/Inexperienced drivers
- Problems with older drivers
- Lane usage (driving too slow in left lane)
- Driver fatigue

TECHNICAL ISSUES

Separate areas or web pages were developed to facilitate an exchange of information and perspectives on cross cutting technical issues related to each of the following five areas:

- Defining benefits and safety risks,
- Technical challenges associated with measuring distraction,
- Equipment design features and design solutions,
- Regulations, guidelines, and enforcement, and
- Safety campaigns and public education surrounding the safe use of in-vehicle technologies.

Unlike the previous technology-specific sections where the focus was on eliciting driver experiences and perspectives associated with various in-vehicle technologies, these pages were intended to explore technical issues by facilitating interaction among experts in the field. Papers, polling items, Q&A from expert panelists, and comments in each of these five technical areas were designed to guide and focus discussions on topics of interest. Over one-quarter of the comments submitted during the conference were posted in the Technical Issues area. While most reflected inputs by professionals working in the human factors, transportation, and safety fields, some useful insights and commentaries were also provided by private citizens. Another avenue used to gather insights on technical issues was an expert panel which took the form of an "Ask the Experts" page. The panel was comprised of 15 noted professionals all working in the field and were available to respond to questions submitted by registered guests on topics of interest to the community at large. In all, responses to 14 questions were posted on the site; the vast majority addressed technical issues and cross-cutting perspectives related to distraction (See Appendix C for a complete list of asked and answered questions). All information gathered during the Internet Forum (particularly information available in the technical issues areas) was used to feed a series of subsequent technical group meetings intended to identify research initiatives to advance our understanding of the driver distraction safety problem and possible solutions.

As with the "Experience with In-Vehicles Technologies" section, moderators were used to periodically synthesized comments, keep discussions focused and moving, emphasize key points, and offer additional insights into related issues. Each of the sections below summarizes discussions within each technical domain addressed during the Internet Forum.

Benefits & Safety Risks

Discussions in this area emphasized safety impacts associated with in-vehicle technological devices. Comments relating to safety risks deriving from non-technological or traditional sources of distraction (e.g., eating, shaving, applying make-up, monitoring kids, etc) were also welcome. Relevant issues to be addressed included, but were not limited to, the following:

- To what extent is there a safety problem? Are problems limited to new users who are first learning to use the system, or are they more pervasive and wide spread?
- How can we maintain benefits without sacrificing safety?
- What can we expect to see in terms of impacts and how do we assess the appropriate level of safety risks from using in-vehicle technologies?
- Can we expect crash rates to increase as a result of in-vehicle technologies?
- How will these technologies affect individual's ability to drive?
- Can drivers be trusted to regulate their use of these technologies – limiting their use to situations when it is presumed safe to operate?
- Will drivers become less cautious as they become routinely exposed to these technologies?
- What are the important unanswered questions relating to safety & benefits of in-vehicle technology. What research issues should we invest our time and resources studying?

"Allowing more technology to interfere with something that demands constant attention will only cause more injury, damage, and eventually grief and expense on American Roads."
- *Private Citizen*

"The benefits certainly do not justify the risk involved."
- Private Citizen

"When these devices [cell phones and navigation systems] are properly setup and the operator is familiar with their operation, they are quite safe."
- *Private Citizen*

"It is great to be able to call someone for direction without having to find a gas station, and even better to be able to see where you are on a computer map."
- Private Citizen

"Future cars could have systems built in that would only be usable when the car is parked. That gives the benefits to those who truly need them, while eliminating most of the risk."
- *Private Citizen*

"There are times when it is perfectly safe for an experienced driver to have a cell phone conversation, have a cup of coffee…"
- *Private Citizen*

Forty-six comments were posted on this page. To a large extent, discussions focused on the benefits and safety risks of cell-phone use while driving; however, some general perspectives regarding other forms of technology and distractions were also discussed. In general, the benefits and safety risks of technology use while driving are unknown. According to poll results, all types of distraction (those resulting from in-vehicle advanced technologies such as cell phones and navigation systems, and more traditional non-technological sources such as eating and drinking) were equally concerning to individuals. This is not surprising given that between 55 and 60 percent of respondents reported witnessing or experiencing a close call resulting from distractions induced by cell phone use as well as other activities. All forms of distraction (not just distraction induced by technology) are perceived to be a problem. Many commented that risks associated with driving alone are significant, and that adding non-driving related tasks to this environment merely serves to compound the problem leading to additional vehicle conflicts and crashes. Although the weight of the scientific evidence collected to date suggests that there is a safety risk with using some in-vehicle devices (cell phones, navigation systems, etc), the magnitude of the risk is uncertain. A number of research studies (available on the site and elsewhere) have attempted to draw relationships between technology use and driving performance and crashes; however, results are not always conclusive and calls for more research are common. Some questioned why available crash records have apparently failed to show significant increases in crash risk despite growing use of these technologies while driving, particularly cell phones. Experts pointed to several reasons, including lack of a widespread and consistent data collection effort by the states to capture and report crashes caused by technologies, as well as the time needed to build sufficiently large and reliable crash databases (crashes are relatively rare events). Others suggested that crash risk may be a function of road and environmental characteristics, as well as individual differences in driver ability to time-share tasks. Some argued, for example, that some drivers are able to divide their attention between driving and other activities and can manage both perfectly well. When asked how capable drivers are at making decisions about when it is safe to use technology while driving, the overwhelming majority of respondents (65%) felt that drivers do a poor job. Only 1 in 5 respondents believed drivers were reasonably or vary capable at regulating their behavior in this manner - limiting their use to situations when it is presumed safe to operate.

"It takes years to be able to develop statistically reliable crash data sets for emerging technologies of any kind…the absence of statistics should never be used as an excuse for inaction when a problem has been recognized."

- *Expert Panelist (Fancis Bentz)*

"The data [showing relationships between cell phone use and crashes] does not exist because it is not collected by state authorities. The situation may soon change as the various jurisdictions examine the issue more closely."

- *Expert Panelist (Michael Goodman)*

"None of the distractions discussed on these postings result in accidents very often… Some road designs are more likely to be associated with accidents than other road designs."

- Automotive Industry

Several papers available on the site assessed the risks and benefits associated with cellular phone use while driving. Both personal and business benefits are typically referenced including more efficient use of time, fewer trips, less stress, increased sense of safety, increased productivity, better traffic management, and faster emergency response times. Comments posted on the site also tended to substantiate many of these benefits. Although the conveniences afforded by these technologies were perceived by many not to be justified given the risks they bring, others argued that the benefits could be realized through judicious use and better designs.

Measuring Distraction: Methods & Techniques

A number of studies have concluded that insufficient data exist upon which to estimate the magnitude of safety related problems associated with the use of in-vehicle devices. Factors contributing to this situation include limitations in crash reporting systems, as well as a lack of valid techniques for measuring distraction. Papers, polls, Q&A items, and comments on this page were oriented to topics and issues associated with the methods and techniques used to measure driver distraction. Suggested topics to be addressed included the following:

- How can driver distraction be safely and rigorously studied in normal driving? How valid are studies that use test tracks, simulators, or laboratory methods?
- What measures (dependent variables) are meaningful indices of driver distraction? How do these relate to roadway safety outcomes?
- What technologies (e.g., physiological monitoring), devices (e.g., eye trackers), or analytic techniques (e.g., steering control inputs) can be used to capture measures of distraction?
- Are there good models that allow you to predict the distracting effects or crash risks associated with a particular distractor?
- What, if any, mechanisms are needed to aid in the investigation of technology related crashes and what tools are needed to support these efforts?
- What are the important unanswered questions relating to the scientific measurement of driver distraction? Where should research resources be directed?

Forty-five comments, accounting for 6% of the total, were submitted on this topic. As indicated by participants and experts, most States lack the means to track how many crashes are caused or influenced by distraction resulting from in-vehicle technology use. This makes it difficult to accurately gauge the effects of in-vehicle technologies on the most obvious safety criterion – vehicle crashes. A number of techniques to assess the safety problem were advanced and discussed. Several calls to integrate "flight recorder" technology into vehicles, for example, were made in order to capture key events and provide needed information to accident investigators. A number of techniques for identifying "distracted" drivers and safety problems were proposed by forum participants; these included the following, among others:

- Measure driver response delays to events (e.g., delays in responding to green traffic signals).
- Construct tests to ascertain drivers' ability to mutli-task (e.g., talk on a cell phone while driving).
- Compare driving ability with and without the use of in-vehicle technologies on a closed driving course.
- Use smart highway technology to monitor distracted drivers.
- Develop tests to measure alertness.
- Use computer vision techniques to monitor drivers and signal them when they become dangerously distracted.

> *"In most states, there is no way of tracking how many collisions are caused or influenced by the use of cellular phones."*
> *- Private Citizen*
>
> *"I see value in being able to retrieve data that could tell accident investigators if these devices were used at the time of a crash."*
> *– Industry Trade Assoc./Society*
>
> *"Some people imply that distraction results in an increase in workload, which may not necessarily be the case. Distraction may simply be a misallocation of resources."*
> *- Auto Industry*

Participants outlined the need to develop accessible and usable methods for creating and evaluating interfaces, and to produce systems that are usable and safe by establishing rigorous design protocols to ensure that in-vehicle systems do not pose safety risks to drivers. Two "Ask the Expert" panel questions submitted by Forum participants addressed this issue. One inquired about the best or most important measure for understanding driver distraction, and the other evaluation measures and appropriate baseline comparative tasks. In response to the first question regarding measures for understanding driver distraction it was argued that the "best" measures for measuring distraction are those which are theory driven, reliable, objective, and generalizable. Several papers, available on the site, investigated the feasibility and usefulness of measuring workload and visual distraction via a Peripheral Detection Task which requires drives to detect and react to peripherally presented stimuli (Martens & Van Winsum, 2000; Olsson & Burns, 2000). A number of surrogate crash safety measures and techniques for assessing distraction were outlined in response to the second question; these include the following:

"There is no single best measure of driver distraction. Objective measures are better than subjective measures. Secondary-task measures of driver distraction offer the best opportunity for success because they can be related to theories of attention."
- *Expert Panelist (Barry Kantowitz)*

"Safety impacts of in-vehicle technologies installed in passenger vehicles can best be inferred from the number of near misses recorded in an instrumented vehicle."
- *Expert Panelist (Valerie Gawron)*

"Should consumers expect to see a safety rating on all systems so they can make relative safety judgments between systems and across different types of systems?"
- *Academia/Research Firm*

- Number of near misses,
- Obstacle avoidance measures such as braking time, level of deceleration and instances of unsafe distances (distance to following vehicle),
- Lane maintenance (lane exceedences), and
- Eye glance measures (glance duration and frequency

Some commented that the safety impact of various in-vehicle technologies can and should be evaluated based on comparisons to generally accepted non-technology tasks, arguing that societal accepted tasks performed while driving (e.g., tuning a radio) can serve as appropriate baselines. Work to develop practical, reliable and meaningful metrics to measure demands imposed by in-vehicle systems was also outlined in a paper submitted by the Crash Avoidance Metrics Partnership (CAMP). When completed the project will yield surrogate measures that can be used by designers and engineers to estimate or measure the distraction potential associated with a given device or function, as well as baseline distributions from which safety criterions can be derived. A current modeling effort was also summarized in a paper submitted by Virginia Polytechnic and State University (Hankey et al, 2000) which describes the development of a prototype evaluation software program for evaluating attentional resources required by In-Vehicle Information Systems. The development of an integrated attention monitoring system and its application for distraction research was also outlined in a Forum paper (Trent, 2000). The system uses an eye-tracking device and can track head pose, gaze, and eye closure in real-time an under real environments.

Equipment Design Features: Impacts on Safety

According to poll results, equipment design features do influence consumer product selections. Approximately 80% of respondents indicated that design and ease of use was an important consideration when selecting and purchasing an in-vehicle device; almost one-third indicated it was the most important factor. Consumers appear to want and demand in-vehicle devices that are easy and safe to operate. Unfortunately, the relative safety impacts of various device designs, options and features are not necessarily well established, much less well understood by users and the driving public. Discussion and content on this page (papers, polling items, comments, etc.) was devoted to topics and issues associated with the impact of equipment design features on driving safety. The emphasis was meant to be on the design features of the technological devices themselves, but comments on system-level safety (e.g., integration of devices, use of crash warnings) were also encouraged. A number of suggested topics were listed to stimulate and focus discussion. These included the following issues and questions:

- What technologies can be employed to develop less distracting devices (e.g.,voice recognition, hands free operation)?
- To what extent does voice interaction (speech recognition, artificial speech) provide benefits over visual presentation? Under what conditions is voice communication distracting?
- Is there less driver distraction with the use of Head Up Displays (HUDs) than with traditional displays? Can everyone use HUDs effectively?
- How should information be structured, formatted, and searched? How much information is too much for drivers to handle?
- What designs and features (design solutions) have worked well in this or similar applications? What problems have been observed?
- What effective countermeasures can be used to combat distraction?
- What are the important unanswered questions regarding the design of in-vehicle technologies? Is research best directed at defining good design or developing tools to evaluate individual designs?

A total of 17 comments addressing equipment design issues were posted on this page, representing approximately 2% of all comments received on the site (note that many comments related to equipment designs were also posted and discussed in other areas of the site as well). These encompassed a range of issues including radio control designs, integration of ITS devices, Head-Up Displays (HUDs), in-vehicle e-mail system designs, and countermeasures. Most comments targeted designs of radio controls. Many agreed that radio designs and controls are needlessly complicated and confusing. Small, multi-functional controls that are poorly labeled and difficult to reach were believed to contribute to the distraction problem and pose threats to safety. A number of solutions were proposed including the use of steering wheel mounted controls with standardized configurations, graphic icons to depict control functions, integrated designs, and large and easy to read main radio controls which are easily distinguished from other buttons.

> *"Radio designs are needlessly dangerous."*
> *- Private Citizen*
>
> *"What is needed is a central control system which is intuitive to operate and easy to use."*
> *- Automotive Industry*

Other technology related features perceived to enhance safety included hands-free devices, safety interlocks which allow drivers to operate devices only when the vehicle is stopped or in park, in-dash cell phones that automatically mute the radio as well as answer incoming calls, and Head-Up Displays that allow drivers to access visual information quickly. Use of speech-based and voice recognition technologies were hotly debated during the Forum and were the subject of a number of papers available on the site. Although this form of communication provides a promising alternative to visual and manual-based interfaces, speech-based interfaces are not necessarily "resource-independent" and some are concerned that drivers may not fully recognize the cognitive demands imposed by these systems. When asked if auditory systems (devices with the capability to interpret voice commands, or communicate using speech messages) are sufficient to address safety concerns associated with operating in-vehicle technologies, participant responses were mixed and varied significantly across affiliation categories. As illustrated in Figure 5, overall responses were fairly equally divided; approximately one-third of respondents believed auditory systems can address this problem only somewhat or minimally. Overall, only 23% thought this feature would adequately address this problem (to a large extent). Those in the automotive industry (Original Equipment Manufacturers and Suppliers) were much more optimistic about the safety benefits of auditory systems than any of the other groups.

> *"Hands-free features are generally safer to use while driving."*
> \- *Private Citizen*
>
> *"Speech-based interfaces may impose cognitive demands that could undermine driving safety."*
> \- *Paper Author (John Lee)*
>
> *"For devices whose use requires viewing a display of some sort, a safety interlock should be installed, which only allows operation while the vehicle is in neutral, or park."*
> \- *Private Citizen*
>
> *'Head-Up Displays should be used in place of dash board located gauges and dials."*
> \- *Private Citizen*

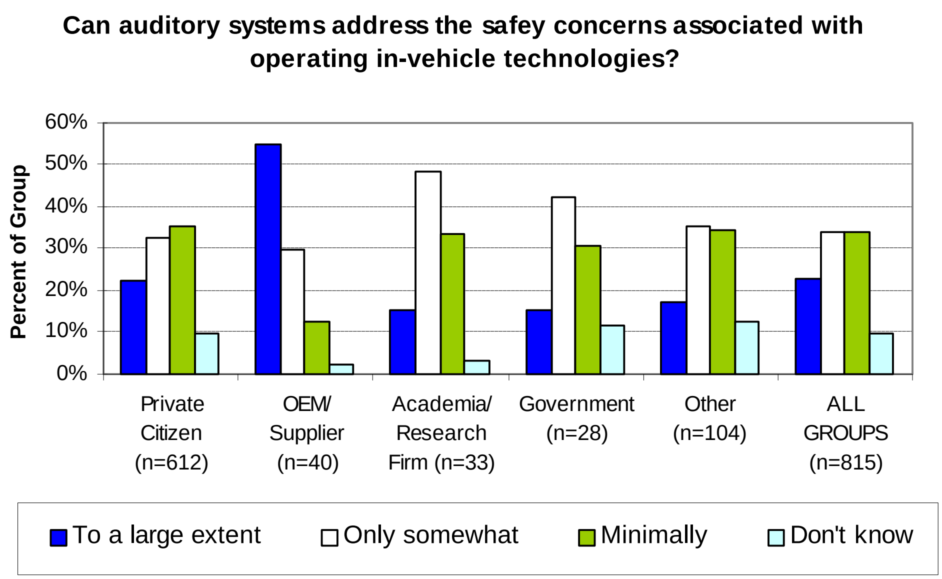

Figure 6. Polling Results Addressing Extent to Which Auditory Systems Are Perceived to Address Safety Concerns. Responses Are Broken Out By Respondent Affiliation.

Of the 24 technical papers posted on the site, seven were devoted to issues concerning device design with several addressing issues directly or indirectly related to auditory systems. Results suggest that speech-based interactions do place a cognitive load on drivers; however, the level of interference associated with auditory communications is less than tasks involving manual or visual interactions. Moreover, acoustically presented information is preferred over visual or manual information. Papers and expert opinions related to the use of Head-Up Displays (HUDs) were also made available.

In additional to specific device designs and features, other driver distraction "countermeasures" were discussed. A number of participants called for the development of "driverless" cars, for example. The role of automation in reducing the driver distraction problem was addressed in a question posed to one of the expert panelist. In his response, Steven Shladover outlined three basic roles for automation: (1) systems that augment driver capabilities (providing additional eyes and ears), (2) systems that can partially replace the driver by assuming some driving tasks, and (3) fully automated systems that can completely replace the driver. Obviously, the distraction problem becomes a moot issue when automated systems are developed which completely take over the driving function. More near-term solutions are represented by the first two options in the form of collision warnings and driver assistance systems. Research conducted by the University of Iowa and available on this site, also supports the use of collision warning to mediate effects of distraction.

"Auditory, haptic and kinesthetic warnings could be very effective at catching the attention of a distracted driver IF they are well designed to elicit the "correct" emergency response from the driver."
- Expert Panelist (Steve Shladover)

"A collision warning system is likely to mitigate the distraction associated with speech-based interactions with in-vehicle computers and cellular telephone conversations, as well as the structural distractions associated with visually demanding tasks."
- *Paper Author (Lee et al., 2000)*
-

"Rear-End Collision Avoidance Systems benefits drivers even when they are not distracted"
- Paper Author (Lee et al., 2000

Regulations, Guidelines & Enforcement

Papers, polls, Q&A items, and comments on this discussion page are oriented to topics and issues associated with alternatives for controlling the design or use of in-vehicle technologies. Suggested discussion topics addressed the following three general themes:

Regulations & Enforcement

- Should there be restrictions on the conditions under which a driver can use a technology? Should such restrictions be controlled through the design of the device or regulations on driver behavior?
- How effective are reckless driving laws in preventing crashes related to driver distraction?
- Are there effective methods to enforce regulations on use?

Safety Principles and Industry Practices

- Are existing principles and industry practices providing adequate controls (e.g., European Commission Statement of Principles, Japanese JAMA Guidelines, Proposed SAE 15 Second Rule)?
- Is there a need for formal standards on the design or use of in-vehicle technologies? In what areas?

Research Needs

- What are the important unanswered questions regarding regulations, guidelines, and enforcement? What knowledge gaps need to be filled in order to develop appropriate guidelines or regulations? How effective are these sorts of controls?

<u>Regulation & Enforcement</u>

According to the National Conference of State Legislatures, although some states impose minor restrictions on cellular telephone in automobiles, few states specifically regulate cellular phone use while driving. In Massachusetts, for example, car phones are allowed provided that drivers maintain one hand on the steering wheel at all times and that the primary driving task remains undisturbed. Nevertheless, a number of states have introduced bills which would regulate or restrict cellular telephones in vehicles; these vary from proposals that would ban all use in vehicles, to requirements for hands-free devices, and restrictions on call length. To date, however, none of the bills have passed.

"There should be a tie between the riskiness of the activity and whether it is banned."
- *Private Citizen*

"Laws that make use of technology while driving might be of some use, but if they're unenforceable, it's a waste of time."
- *Private Citizen*

"There are a multitude of distractions facing drivers. Regulating only one of these factors would be unfair."
- *Private Citizen*

"When people can't accept responsibility for their actions, it's time to regulate them."
- *Private Citizen*

The issue of regulation was one of the most hotly debated topics discussed on the Internet Forum; this was particularly evident in discussions associated with cell phone use while driving. Many argued that the only effective way to increase safety is to ban or severely restrict use of "dangerous" in-vehicle technologies and activities that have been demonstrated to be hazardous. Indeed, the vast majority of respondents (74%) felt that cell phone use while driving should be regulated; even 63% of registered cell phone users agreed that States or local governments should enact laws to restrict the use of cell phones while driving. Opponents argued that regulation was not an effective alternative for several reasons:

- Laws would need to be created for each and every form of distraction.
- Laws already exist governing driver behavior (reckless driving, failure to pay full attention to the road, etc.).
- Unrealistic to expect these laws to be enforced and therefore this approach would not be effective. Need to enforce existing laws rather than create new ones.
- Bans or restrictions are not effective at regulating behavior.

> *"Many countries in Europe have banned cell phone use while driving because it was found that phone use was becoming a problem. They did not wait for statistics and numbers in order to recognize and act on the problem."*
> - *Private Citizen*

The impact of cell phone regulation in Japan requiring the use of hands-free devices was also the subject of an "Ask the Expert" question. In his response, Hiroshi Tsuda cited data collected by the Japanese National Police Agency suggesting that following the ban crashes caused by cell phones resulting in fatalities or injuries fell approximately 75 percent. Mr. Tsuda cautions against attributing all of the decline to the ban against hand-held devices since drivers may have simply refrained from using the phone, exercised extreme care when using hand-held devices, or simply failed to report using the phone during the interval following the ban. Nevertheless, data in Japan appears to support the view that restrictions on technology use can impact safety. Many participants, and paper authors, suggested investigating the effectiveness of bans and restrictions in other countries as well (A number of papers available on the site addressed the effectiveness of regulation as well as the cost/benefit of this approach in the context of cell phones). In the Internet Forum, the regulation debate appears to distill down to the basic views. Those against technology bans and restrictions tend to view these initiatives as a challenge to their personal rights and freedoms, while those in favor of regulation tend to perceive an underlying public safety threat and lack of personal responsibility. Many, however, perceived bans on technology to be impractical, and suggested restrictions in the use of the technology or changes in design (e.g., hands-free devices, interlocks, etc.) would be more effective and should be considered as possible viable solutions. Nearly all believed that passengers should have full unrestricted use of in-vehicle technologies and not be precluded from using available technology – the problem is driver-centered.

<u>Guidelines</u>

> *"…it is clear that distraction must have been very much on the Commision's mind when it formulated the overall design principles [European Statement of Principles on In-Vehicle HMI]."*
> *- Paper Author (Janssen, 2000)*
>
> *"…although some progress in research and international standards has taken place, there remains the issue of how to assess in-vehicle safety or even the extent to which a specific in-vehicle information system supports the safety and effectiveness of principles of the European Commission."*
> *- Paper Author (Stevens & Rai, 2000)*

Others have commented that designers and engineers need accessible and usable guidelines for creating and evaluating interfaces that are compatible with safe driving. Ideally, guidance should be applicable during the early stages of design to prevent costly reengineering once a product is brought to market, and should be expressed in terms useful for product design engineers. Although preliminary guidelines for the design of safe and usable driver information systems now exist, and more are under development both in the U.S. and internationally, some have expressed concern over the relative paucity of guidance which tends to be overly general and incomplete. Limited discussions addressing guidelines took place on the Internet Forum, however, several papers outlining and critiquing existing practices and guidance were posted on the site. One paper (Stevens & Rai, 2000, available on the site) outlined a checklist approach to assessment which allows experts to make evaluate key features on in-vehicle systems. Another (Janssen, 2000) provide a detailed critique of the European Comminsion's Statement of Principles with respect to recommendations for preventing driver distraction caused by in-vehicle HMI. Finally, comments clarifying the scope and potential expansion of the proposed SAE Recommended Practice J2364 were provided by the document's author.

> *"The 15-Second Total Task Time Rule is supported by the literature for the purpose for which it was intended, using manual controls and visual displays associated with navigation systems. Extensions of the 15-second limit beyond navigation systems with manual controls and visual displays should be done with great care…"*
>
> *- Academic/Research Firm & Standards Author*
>
> *"European experts working on the further specification of the principles are considering the proposition that four glances off the road for not longer than two seconds for any glance should be considered as a practical limit. The idea that there should be this type of discrete and, in fact, unidimensional cutt-off criterion is probably untenable."*
>
> *- Paper Author (Janssen, 2000)*

Safety Campaigns & Public Education

Papers, polls, Q&A items, and comments on this page were oriented to topics and issues associated with safety campaigns and public education regarding the safe use of in-vehicle technologies. Discussion issues and topics were meant to address the following:

Safety Campaigns

- What information should be provided in public service announcements and how effective will it be? Who are the target drivers and how can they be reached?
- What information does the public need, as drivers or as consumers of technology products?
- How effective is the provision of safety tips? Do we understand the problem well enough to provide good tips?

Public Education

- Is there a "learning curve" that makes the distraction risk particularly great for novice users of a technology or a specific product? Is there some way that training or practice could be introduced to minimize this?
- Is there a need to introduce driver distraction/technology use into driver education curricula? Do novice drivers potentially have greater distraction problems and can training help with this?

Although few comments were posted on this page, issues associated with safety campaigns and public education were evidenced throughout the web site. The need for educating drivers on the responsible and safe of use in-vehicle technologies such as cell phones was clear. Some participants proposed that the majority of drivers cannot discern situations and environments when it is safe versus unsafe to use a cell phone when driving. Poll results indicate this opinion is shared by many who generally perceive drivers as unable to make decisions about when it is safe to use technology (65% of respondents felt drivers do a poor job at making these judgments). This finding highlights the need to educate the public on the safe use of devices while driving.

Another basic issue dealt with the perceived effectiveness of education and its impact on behavior and safety. When asked if public education and training about the safe use of in-vehicle technologies would increase safety, the majority of poll respondents (56%) felt education would have some positive impact on safety. Nevertheless, as illustrated in Figure 7, many respondents (43%) believed that education's impact on safety would be minimal. Skeptics questioned whether this approach would work given the relative "failure" of existing driver training and education programs. Others expressed skepticism that educational campaigns and safety tips about the safe use of technology would actually translate into action (behavioral changes). Polls taken on the Internet Forum suggest that many drivers, but not all, would change some aspects of

"…drivers need to learn how to use them [in-vehicle technologies] safely, under the proper circumstances, without jeopardizing themselves and others."
- Joan Harrris, NHTSA

"Driver education is the secret to safer highways"
- Public Citizen

"Public awareness training will be ignored. The chronic cell ohone user is too self-absorbed to change their behavior."
- Private Citizen

"Safety will not become an issue for drivers until they realize they are vulnerable."
- Private Citizen

"…education is important, especially supported by enforcement and engineering. However, I believe there is a major problem with training and education as they are now deployed."
- Private Citizen

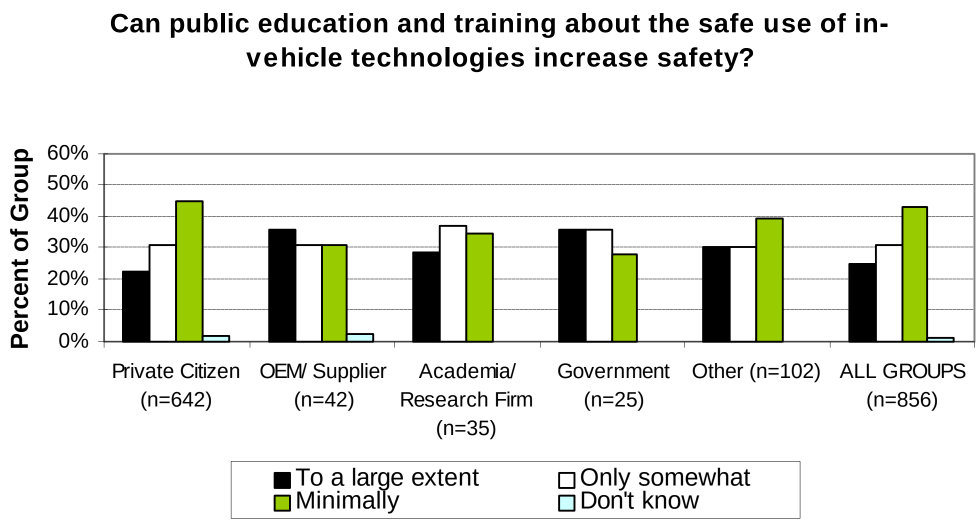

Figure 7. Polling Results Addressing Extent to Which Education & Training About The Safe Use of In-Vehicle Technologies Will Increase Safety. Responses Are Broken Out by Respondent Affiliation.

their behavior as a result of education and/or safety tips. As indicated in Figure 8, nearly 40% of respondents report having changed how they use their cell phone while driving as a result of a safety tip they saw or heard. Some participants relayed personal testimonies about changes in their use of technology as a result of safety campaigns, tips about technology use, and/or personal experience with close calls. Together, these results suggest that safety campaigns and education on technology use can be effective, although reliance on this alone is not likely to address all of the safety concerns with in-vehicle technologies.

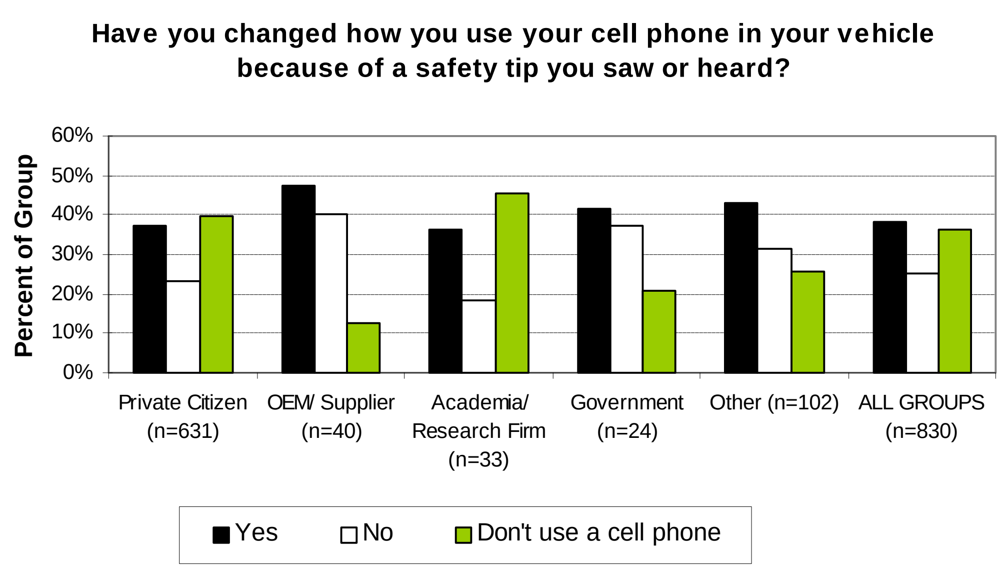

Figure 8. Polling Results Addressing Extent to Which Safety Tips Affect Cell Phone Use. Responses Are Broken Out by Respondent Affiliation.

SUMMARY & CONCLUSIONS

The Internet Forum, sponsored by the National Highway Traffic Safety Administration (NHTSA), provided a unique opportunity for technical experts and the public (both in the U.S. and internationally) to download research papers, ask questions, and share experiences regarding the use of in-vehicle devices (cell phones, navigation systems, wireless Internet, information & entertainment systems, night vision systems, etc.). Over 9,500 visitors and 2,600 registered guests logged onto the site over the five-week conference period, contributing a total of 700 comments. Although all forms of distraction (not just distraction induced by technology) were perceived to be a problem by Forum participants, discussions were primarily focused on the use of in-vehicle technologies. Important Forum highlights and key points are summarized below.

- The benefits and safety risks associated with the use of in-vehicle technologies are not very well understood. It is difficult to accurately gauge the effects of in-vehicle technologies on the most obvious safety criterion – vehicle crashes. Lack of crash data and problems with reporting systems make it difficult to establish causal links between technology use and vehicle crashes. Practical, reliable and meaningful measures for assessing distraction and appropriate baseline tasks are needed. The safety impacts of various device designs also need to be determined. Several papers available on the site focused on issues related to benefits and safety risks; some even attempted to derive benefit/cost ratios. All tended to indicate that more research is needed to capture both risks and benefits associated with technology use while driving.

- While the conveniences afforded by advanced in-vehicle technologies were perceived by many participants to be unjustified given the risks they bring, others argued that benefits could be realized through judicious use and better device designs. Many argued that safety could be achieved through user-friendly designs, speech-based technology, and/or designs that limit interactions such as interlocks which prevent drivers from accessing information or performing complex tasks when the vehicle is in motion. Key system design features perceived to impact the safety and utility of these systems included the location of displays and controls, content of the displays, interaction modes, and accessibility to certain functions while driving. Others indicated that, irrespective of design, consumers must practice responsible use of the technology; if drivers cannot exercise appropriate judgment then some form of regulation may be warranted.

- Solutions to perceived problems generally fell into one of three categories: system design, education & training, and enforcement & regulation. Many perceived bans on technology to be impractical. Nearly all believed that passengers should have full, unrestricted use of in-vehicle technologies (the problem is driver-centered).

- One growing concern associated with the use of in-vehicle technologies was the loss of situational awareness and the ability to practice safe, defensive driving. Many argued that while the physical and visual demands associated with interacting with in-vehicle technologies are addressable through user-friendly product designs (e.g., speech-based modes), the cognitive aspects of interacting with technology present challenges and concerned many participants. Cognitive distraction is troublesome because it is harder to measure and perhaps more insidious than manual or visual demands associated with device interaction. Although this type of cognitive distraction is not unique to in-vehicle technologies, exposure was believed to be dramatically increased via introduction of advanced in-vehicle devices such as cell phones and wireless Internet systems.

- Although responses to polling items were non-scientific and not necessarily representative of drivers in general, some interesting differences in perspectives emerged across various affiliation groups. Those working in the automotive industry (Original Equipment Manufacturers and Suppliers), for example, were generally more optimistic about the ability to develop systems that are compatible with safe driving practices. These groups tended to view speech-based technologies (auditory systems) as a means to achieve safe designs.

- Most participants tended to believe that drivers generally do a poor job at making decisions about when it is safe to use technology while driving. Individual difference in driver age and experience as well as differences in driving conditions were perceived to affect drivers ability to safely interact with these systems while driving.

- Noticeably absent were comments relating to the use of handheld PCs or Personal Digital Assistants (PDAs) which are gaining in popularity. This class of technology is important since it represents devices which, like cell phones and pagers, are not necessarily designed for automotive applications; nevertheless, drivers can bring them into their vehicles. The basic issue is how to design or allow for the integration of these types of "aftermarket" devices into the driving environment without sacrificing safety. The Society of Automotive Engineers' ITS Safety & Human Factors Committee is currently considering whether to pursue the development of some form of industry-wide standard or recommended practice regarding PDAs (consistency of controls, displays and operating characteristics, etc.) to facilitate their use in vehicles and minimize distraction induced by these technologies.

- The overwhelming majority of participants (75%) felt it was not safe to talk on a cell phone while driving; holding a conversation, doing cell-phone related tasks (e.g. jotting down notes), and dialing a telephone number were among the biggest safety concerns. There was, however, considerable disagreement concerning what specific actions or steps are needed to address this growing problem. Regulatory solutions (bans, restrictions, equipment requirements), enforcement of existing laws, education and safety campaigns, better equipment designs, standards, and interlocks were all proposed as possible solutions to the growing problem of cell phone use while driving.

- Safety campaigns and education about technology use while driving were thought to be effective, although reliance on this alone is not likely to address all of the safety concerns associated with the use of in-vehicle technologies.

- Both technology and non-technology users appeared to share some basic concerns about the responsible use of technology while driving. Nearly two-thirds (63%) of individuals who report using cell phones in their vehicles, for example, believed it was not safe to use a cell phone while driving and that some form of regulation was warranted. Further, although experience with in-vehicle technologies was perceived by some to lead to more responsible use, many felt that most drivers do a poor job of making decisions about the use of technology while driving. Technology users also appeared more inclined to agree that designs could be developed allowing systems to be safely used while driving.

APPENDIX A:
SUMMARY OF INTERNET FORUM PAPERS

Authors/Title	Purpose/Description	Major Findings & Conclusions
CELL PHONES		
Crash Risk & Association with Crashes		
Redelmeier & Tibshirani (1997) *Association Between Cellular-Telephone Calls and Motor Vehicle Collisions*	Examined whether cellular telephone calls were associated with motor vehicle collisions. Used case-crossover design (interviewed drivers involved in a collision between 1994-1995 who also owned a cellular telephone). Canadian drivers.	▪ Found drivers were 4 times more likely to be involved in a collision when using a telephone compared to when they were not using a telephone (For reference, driving with a BAC at the legal limit is associated with a risk factor of 4, and a BAC 50% above the legal limit is associated with a risk factor of 10). ▪ Experienced drivers showed a similar collision risk factor of 4.1, suggesting the association is not merely a reflection of inexperience, but due to a basic limitation in driver performance. ▪ Hands-free phone appeared to offer no safety advantage (relative risk of 5.9), suggesting the problem is related to limitations in attention. ▪ Authors suggest avoiding unnecessary calls, keeping conversations brief, and suspending use under hazardous circumstances.
Goodman et al. (1997) *An Investigation of the Safety Implications of Wireless Communications in Vehicles*	Assessed current state of knowledge regarding the impact of cellular telephone use while driving. Examined: (1) whether cell phone use increases the risk of a crash, (2) the magnitude of the traffic safety problem, (3) estimated impact of increasing cell phone usage, (4) options for enhancing the safe use of cell phones by drivers.	▪ Available evidence suggests that cell phone use while driving increases the risk of a crash. Conversation appears to be most associated with the crashes. ▪ Insufficient data exist upon which to estimate the magnitude of any safety-related problem. Current reporting systems are inadequate. ▪ All else being equal, crashes are likely to increase as the use of in-vehicle wireless communications technology increases. ▪ Negative effects may be minimized if drivers are aware of hazards, are judicious in their use of the technology, and if ergonomically sound telephone designs are used. ▪ Recommends development of improved data collection and reporting systems, improved consumer education programs, and more research to better understand naturalistic driver behavior while using cell phones and workload reducing design features.
Lissy, Cohen, Park & Graham (2000) *Cellular Phone Use While Driving: Risks and Benefits*	Assessed the risks and benefits associated with cellular phone use while driving.	▪ Weight of scientific evidence suggests there is a safety risk, but the magnitude of these risks is uncertain. ▪ More precise exposure data are needed. Current estimates suggest that most calls last between 30 seconds to 2 minutes. ▪ Information about the influence of cell phone use in crashes is difficult to obtain; with few exceptions, police reports do not elicit this information. ▪ No state has yet passed a law to prohibit phone use while driving. ▪ Concluded that crash data as a whole do not provide

Authors/Title	Purpose/Description	Major Findings & Conclusions
		convincing evidence that cell phone use while driving is associated with an increase in the number of fatalities or collisions. ▪ Policymakers need to consider the risks and benefits of drivers switching to other communication devices (e.g., hands-free phones, pagers, etc). ▪ A prohibition on the use of cellular phones while driving appears to be a relatively inefficient investment in traffic safety. Better scientific information on both benefits and risks need to be collected. (Recommendations) ▪ Develop jointly funded program on the risks and benefits of wireless communications in the transportation sector. ▪ Replicate major studies (e.g., Redelmeier & Tibshirani, 1997) in several geographical locations. ▪ Conduct international comparison studies to determine the impact of different policies on risks and benefits of cell phone use while driving. ▪ Develop better approaches for determining whether a particular crash is cell phone related (surveillance and reporting practices). ▪ Implement a broad-based driver distraction research program. ▪ Develop comprehensive educational effort aimed at promoting responsible cell phone use while driving.
Conversation & Influence on Situational Awareness		
Parkes & Hooijmeijer (2000) *The Influence of the Use of Mobile Phones on Driver Situational Awareness*	Simulator study examining the influence of cell phone use on driver situational awareness. Driving performance of 15 subjects, aged 22-31, (both with and without a hands-free telephone) was assessed while conversing on a cell phone. The phone task consisted of a selection of numerical questions.	▪ Found significant deterioration in situational awareness across the phone and no-phone situations. Drivers engaged in phone conversations had significantly fewer correct answers in repose to situational awareness questions. ▪ Some evidence suggests that drivers are slower to react just after the start of the conversation, but the effect is minimized over time. ▪ Drivers were found to be slower to adapt to a change in speed from 80 to 50 km/h when engaged in a conversation. ▪ Authors highlight the need for further study into the nature and duration of typical carphone conversations.
Harbluk, Noy, and Eizenman (2000) *The Impact of Internal*	Describes a planned study to examine the impact of internal distraction created by the processing of information in the	▪ Study has yet to be completed, but will improve our understanding of the relationship between cognitive load and visual behavior. Three levels of cognitive task demands will be explored and their effects on a

Authors/Title	Purpose/Description	Major Findings & Conclusions
Distraction on Driver Visual Behavior	course of interacting with or conversing over a hands-free in-vehicle device. Sixteen subjects between the ages of 21-35 will drive a Toyota Camry equipped with an instrumentation system. A portable eye-tracking apparatus will be used to examine mechanisms underlying the narrowing of visual attention. Arithmetic questions of varying difficulty will be presented over a cell phone.	range of measures assessed (including vehicle control, visual behaviors using an eyetracker, video and audio data, and subjective assessments of workload and driving impact).

Other Cell Phone Related Issues

Hahn & Tetlock (1999) *The Economics of Regulating Cellular Phones in Vehicles*	Conducted an economic analysis of regulatory options for addressing cellular phone usage by drivers in the United States. Examined a ban on cell phone use as well as regulation requiring the use of a hands-free device. Authors point out that their analysis probably overestimates the costs of a regulatory intervention on cell phone use and the number of accidents reduced by the intervention given by perfect enforcement. The also recognize that the analysis fails to consider important factors that could bias the results such as costs to users of cell phones in vehicles.	▪ Concluded that the economic costs of a ban on cellular phone use in vehicles far outweighs the benefits. Estimated benefits of a cell phone ban to be $1.2 billion (attributable to a reduction in fatalities and injuries associated with phone use) and costs to be $25 billion per year (attributable to costs to cell phone users and producers). ▪ Hands-free regulation would fail a benefit-cost test unless it resulted in a 30% reduction in accidents related to cellular phone use. ▪ Argued phone use in vehicles does not currently appear to contribute to a large number of accidents (estimated to be under 0.2% of total accidents) ▪ Authors recognize that available data suggests that drivers' cell phone usage does lead to an increase in accidents and fatalities, but question that government policies would significantly reduce the size of the problem. ▪ Authors recommend carefully monitoring the problem and called for collecting more systematic information on the relationship between cell phone use and driving accidents.

DEVICE DESIGN (SPEECH-BASED SYSTEMS, HUDs, INTEGRATION)

Lee, Caven, Haake, & Brown (2000) *Speech-Based Interaction with In-Vehicle Computers: The Effect of Speech-Based E-mail on Drivers' Attention to the Roadway*	Evaluated the distraction potential of speech-based interfaces (in the context of an e-mail system) using a driving simulator. Two voice activated e-mail systems studied: simple and complex (varying in the number of menu options); each with voice recognition and text-to-speech interfaces. Both were examined	▪ Drivers responded more slowly to lead vehicle decelerations when the e-mail system was available than when it was not available (reaction times were increased by 30%, or by 310 msec.) ▪ Authors suggest the effect of a 300-msec delay in reaction time may translate into a 3.5-38.5 increase in collisions and a 27.3-80.7% increase in collision velocity; increasing collision rates and severity. ▪ System complexity did not increase driver reaction time, but it did impact perceived distraction and

Authors/Title	Purpose/Description	Major Findings & Conclusions
	under complex and simple driving environments. Subjects were 24 drivers aged 18-24, and exposed to the system for 1 hour. Measured driving performance, situational awareness, subjective workload, and perceived distraction.	workload. ▪ Authors conclude that speech-based interactions place a cognitive load on drivers that can affect driving performance. Suggested future research should examine how well drivers' perceived distraction corresponds to the actual level of distraction
Vollrath & Totzke (2000) *In-Vehicle Communication and Driving: An Attempt to Overcome Their Interference*	Examined effects of three in-vehicle communication types (manual, visual and auditory) on driving performance under curved and straight driving conditions. Driving simulator with 30 subjects, mixed factorial design.	▪ Not all communication tasks interfere with driving. Tasks involving manual operations cause the greatest interference, followed by visual and auditory information processing tasks. Acoustically presented information is preferred over visual or manual information. ▪ Visual information processing negatively influences driving on curvy roads leading to deteriorated longitudinal and lateral control. ▪ Manual interactions result in poor longitudinal and lateral control on straight and curved roads. ▪ Driver support systems have to be adapted to different kinds of in-vehicle interactions. If systems rely on visual information processing, introduction of a lane keeping driver assistance system would be desirable. When manual inputs are required, driver assistance systems should aid in lane keeping and headway maintenance. ▪ The driving task was also found to have a negative effect on the performance of the communication tasks.
Tijerina, Parmer, and Goodman (1998) *Driver Workload Assessment of Route Guidance System Destination Entry While Driving: A Test Track Study*	Examined route guidance system destination entry tasks across four commercially available systems representing different entry and retrieval methods. Test track study using 16 subjects consisting of young /old drivers and males/females. Cellular dialing and radio tuning tasks were included for comparison.	▪ Age was found to influence visual allocation, driver performance and destination entry times. Age differences were minimized via voice destination entry. ▪ Voice recognition technology is a viable alternative to visual-manual destination entry while driving. ▪ Future research should examine effects of these systems on driver object and event detection.
Kiefer (1998) *Quantifying Head-Up Display (HUD) Pedestrian Detection Benefits for Older Drivers*	Examined benefits of Head-Up Displays (HUD's) for older driver pedestrian detection. Closed test track. Twenty-four subjects (13 males, 11 females) ranging in age from 59-71 years (mean age 65) were asked to perform speedometer reading tasks with both a head-up and head-down display. On some trials, pedestrians were positioned in the forward scene and drivers were	▪ HUDs improved older driver's ability to see forward scene events. HUDs enabled drivers to more quickly detect pedestrians and with fewer missed detections. ▪ Results suggest that HUDs will reduce the incidence of crashes caused by allocating visual attention to head-down displays.

Authors/Title	Purpose/Description	Major Findings & Conclusions
	required to press a button as soon as they detected the pedestrian.	
Kantowitz & Moyer *Integration of Driver In-Vehicle ITS Information*	Overviews system integration issues and research needs associated with ITS and in-vehicle information systems. Highlights human factors lessons learned from the aviation domain and outlines research needs for next-generation IVI vehicles equipped with advanced technologies. Discussions are limited to human-centered integration issues – aspects of the driver-machine interface that are perceived and manipulated directly by the driver.	▪ Potential ITS in-vehicle systems can be grouped into 3 categories: CAS, ATIS, and convenience and entertainment systems. Systems must blend information, communication, and entertainment technologies without complicating the basics of operating vehicles. ▪ In aviation, the human operator serves as the driving force behind system design. One successful approach is to limit information presentation - information the pilot does not need is not displayed (dark and silent cockpit). Pilots can also request information not currently displayed. ▪ Allocation of function can be fixed, or changed dynamically by the driver or system. Care must be exercised to ensure the mode of operation is clearly understood. ▪ Integration of warning systems and In-Vehicle Information Systems represent two high-priority research areas. Specific issues include: message prioritization, driver overload, false alarms, display modality, voice activation. ▪ Guidelines exist to aid integration.
MEASUREMENT		
Martens & Van Winsum (2000) *Measuring Distraction: The Peripheral Detection Task*	Investigated the feasibility of measuring workload via a Peripheral Detection Tasks (requiring drivers to detect and react to a peripherally presented stimuli). Assessed whether the technique is sensitive to sudden and short increases and variations in workload. Computed average reaction time and fraction of missed signals for several driving situations (e.g., braking lead vehicle, stop sign, sharp curve. Study conducted using a driving simulator with 54 subjects.	▪ The Peripheral Detection Task (PDT) is suitable for measuring variations in workload. Both reaction time and misses to peripherally presented targets are sensitive to differences in driving situations. ▪ PDT is also sensitive to differences in workload associated with non-visual in-vehicle messages.
Olsson & Burns (2000) *Measuring Driver Visual Distraction with a Peripheral Detection Task*	Evaluated the usefulness of a Peripheral Detection Task for measuring workload and visual distraction in real road-traffic environments. The PDT required drivers to respond to random targets presented peripherally. Thirteen subjects drove a Volvo	▪ The PDT appears sensitive to different in-vehicle tasks. Both PDT measures revealed significant differences among the different tasks. Mean reaction times were slowest for the backward counting task and hit rates were worst for the CD task. ▪ More research is needed to validate the use of the PDT across a wider range of tasks and driving conditions. ▪ PDT measures could be used to define some absolute

Authors/Title	Purpose/Description	Major Findings & Conclusions
	S80 on motorways and country roads while performing different tasks (changing CD's, tuning radio, backward counting). PDT reaction time and hit rate were measured and compared with other workload measures (subjective mental workload and objective ECG signals).	criterion for driver distraction (e.g., hit rates of less than 65% and reaction times slower than 800 ms). More research is needed to establish "unsafe" PDT performance values.
Victor (2000) *A Technical Platform for Driver Inattention Research*	Describes the development of an integrated attention monitoring system and its application for distraction research. The system includes a unique head and eye-tracking device which is integrated with vehicle performance data. Tracks head pose, gaze, and eye closure in real-time , in real environments.	▪ Demonstrated 95% tracking reliability. ▪ System can differentiate between targets such as the speedometer and tachometer, and can measure head and gaze when the driver is wearing glasses (head pose only with sunglasses). ▪ Platform provides opportunities to capture real-time driver visual behavior under realistic settings. Planned study uses are highlighted.
Tijerina (1999) *Issues in the Evaluation of Driver Distraction Associated with In-Vehicle Information and Telecommunications Systems*	Examines several issue related to the evaluation of driver distraction.	▪ Comprehensive safety evaluations should consider both the demand when a device is used, and also the incidence of device use. ▪ Despite its problems, hazard analysis methods can play a vital role in early system evaluation. ▪ Need to develop links between distraction and safety.
CAMP (2000) *Proposed Driver Workload Metrics and Methods Project*	Effort focuses on obtaining measures of demands imposed on drivers by in-vehicle systems and relating them to measures of driving performance. Objective is to develop practical, repeatable and meaningful metrics to measure demands imposed by in-vehicle systems. These surrogate measures can be used to estimate or measure the distraction potential associated with a given in-vehicle device or device function.	▪ Attempts to predict crash incidence based on driver workload is subject to substantial errors of prediction. ▪ Proposed alternate evaluation approach uses conventional in-vehicle tasks to develop baseline distributions from which safety criterions can be derived. ▪ Project will produce a set of surrogate metric and methods which can be used in assessing system demands. Surrogate measures (Static task time, TLX Scores, etc.), will correspond with one or more ground thruthed workload measures (e.g., number of eye glances, brake RT, etc).
COUNTERMEASURES		
Lee, Ries, McGehee, & Brown (2000) *Can Collision Warning*	Studies were conducted to identify how well rear-end collision avoidance systems (RECAS) can mitigate the	▪ RECAS provides a safety benefit to both distracted and undistracted drivers. ▪ RECAS found to reduce the percentage of imminent collision situations ending in a collision and decrease

Authors/Title	Purpose/Description	Major Findings & Conclusions
Systems Mitigate Distraction Due to In-Vehicle Devices?	distraction induced by a visually demanding task, and the extent to which RECAS aids non-distracted drivers in avoiding an imminent collision. The first study examined different warning algorithms (early versus late warnings) using 120 drivers (aged 25-55); and the second studied RECAS benefits using 20 undistracted drivers (aged 25-55). Both studies used a high-fidelity simulator.	collision velocity. Early warnings produced the greatest benefit reducing the rate of collisions to 8.8% compared to a baseline of 45.5%. ▪ Warnings influenced how quickly drivers released the accelerator; early warnings led drivers to react more quickly than late warnings.
GUIDELINES & DESIGN AIDS		
Hankey, Dingus, Hanowski, & Wierwille, (2000) *The Development of a Design Evaluation Tool and Model of Attention Demand*	Describes the development of a prototype evaluation software program designed to aid human factors designers and engineers in evaluating the attentional resources required by IVIS designs.	▪ Program may be used to compare two or more candidate designs against their attentional demands, or evaluate designs against benchmark criteria (e.g., safety related measures). ▪ Allows driver, environmental, display, and task factors to be considered, and yields individual demand metrics across five resource categories (visual, auditory, supplemental information processing, manual, and speech) as well as an overall figure of demand to assess the attention demand of the driver. ▪ A total of 198 tasks are included in the prototype IVIS DEMAnD program. Additional tasks can be programmed into the design tool.
Burns & Lansdown (2000) *E-Distraction: The Challenges for Safe and Usable Internet Services in Vehicles*	Outlines safety issues related to IVI systems and discusses some preliminary human factors solutions for the design of driving-compatible interfaces. Focuses on usability challenges to be overcome for safe and usable Internet services in vehicles. Overviews a number of guideline documents available in the literature which address in-vehicle system designs as well as basic human factors design principles.	(Safety Principles) ▪ Systems must minimize loading time; once information is requested it should be immediately available. ▪ Information should be presented in a standard and predictable format and structure. ▪ Systems should take into account individual differences such as age and experience. ▪ Placement of controls should not contribute to unnecessary distraction from the forward view. (Future Needs) ▪ Need to establish how adherence to design principles (e.g., European Commission statement of principles) will be ensured. ▪ Development of an architecture that will manage information to be presented to drivers. ▪ Techniques for distinguishing between the driver and passenger.
Stevens & Rai (2000)	Describes the development of safety principles for in-vehicle	▪ Addresses the issue of how to assess in-vehicle safety and the extent to which specific vehicle information

Authors/Title	Purpose/Description	Major Findings & Conclusions
Development of Safety Principles for In-Vehicle Information and Communication Systems	information and communication systems. Highlights the historical development of the European Commission's Statement of Principles, consisting of 35 principles, which frames key issues to be considered for in-vehicle driver information and communication systems.	system supports the safety and effectiveness principles of the European Commission's Statement of Principles. ▪ Overviews a checklist approach which enables experts to make rapid and structured assessment of key in-vehicle system features, and can be used to identify problem areas requiring further quantitative assessments. ▪ Overviews challenges associated with quantifying and testing guidelines, and defining acceptable levels of distraction (benchmarks)
Janssen (2000) *Driver Distraction in the European Statement of Principles on In-Vehicle HMI: A Comment*	Reviews the European Commision's Statement of Principles with respect to recommendations for preventing driver distraction caused by in-vehicle HMI. Items addressing driver distraction are scrutinized for how well they achieve their intended purpose.	▪ EC statement omits a potentially negative effect of in-vehicle support, namely adaptation of driver behavior and risk compensation. ▪ Many are items are redundant. ▪ Highlights the ongoing debate over the quantification of the maximum allowable task load. ▪ EC statement would benefit from further specifications of the principles. Many are broadly phrased and underspecified questioning their utility and effectiveness. ▪ Future specification may set a criterion of no more than 4 glances off the road each no longer than two seconds. Argues that development of this type of discrete and unidimensional cut-off criterion is probably untenable, and that equivalencies (trade-off between glance duration and number of glances) should be incorporated into the principles. ▪ The principles do not contain a specification of allowable auditory task load, nor that of the combined load on the auditory and visual channels. ▪ As a whole, the document fails to address the drivers' own capacity to regulate the level of distraction they will accept.

INDIVIDUAL DIFFERENCES

Tijerina, Parmer, and Goodman (1999) *Individual Differences and In-Vehicle Distraction While Driving: A Test Track Study and Psychometric Evaluation*	Investigated the influence of individual differences on driver distraction. Test track study using 16 subjects and destination entry tasks using commercially available route navigation systems. Driving performance on the test track was related to performance on a battery of temporal visual perception and cognitive tasks.	▪ Low but consistent correlations were found between test-track and test battery performance measures. ▪ Additional work is needed to refine relationships between specific task demands and predictor sets.
Mourant, Tsai, Al-Shihabi, & Jaeger	Examined young and older drivers' ability to divide attention	▪ Superimposed displays yielded more accurate performance than images presented using the in-

Authors/Title	Purpose/Description	Major Findings & Conclusions
(2000) *Divided Attention Ability of Young and Older Drivers*	when using in-vehicle ATIS as a function of display format (in-vehicle and superimposed on a virtual display). Also varied the time between stimulus presentations. Twenty subjects (ten in each of two groups, aged 23-46 and aged 58-76). Simulator study. Drivers' task was to steer the vehicle and report the four random digits presented.	vehicle display. ▪ Older drivers were less able to keep the vehicle in the lane when using the in-vehicle display than young drivers; performance (time outside the lane) using the superimposed display was comparable for both age groups.

GENERAL REFERENCE/MISC

Ranney, Mazzae, and Goodman (2000) *NHTSA Driver Distraction Research: Past, Present, and Future*	Summarizes NHTSA research in the areas of driver distraction and workload, and overviews current ongoing and future NHTSA research.	▪ NHTSA's first major effort, launched in 1991 addressing truck driver workload, concluded that quantitative models to predict crash incidence as a function of workload are not currently feasible. Workload is best considered as a relative assessment in comparison to other tasks or baselines. ▪ NHTSA assessed impact of wireless phone use in 1997. Although phone use is likely to increase the risk of a crash, the magnitude of the problem cannot currently be estimated. ▪ NHTSA conducted a series of route navigation system studies: a destination entry study, an individual driver difference study, and an assessment of SAE's "15-second rule." ▪ Current research includes an AutoPC test track study comparing voice and manual interfaces and the distraction potential of AutoPC transactions; and, a naturalistic study to evaluate wireless phone interfaces. ▪ Future research will use NADS to extend on-road research using more workload intensive technologies, and better understand the safety benefits and tradeoff of night vision systems.

APPENDIX B:
POLLING ITEM RESULTS

	Private Citizen	OEM/ Supplier	Academia/ Research Firm	Government	Other	TOTAL
In terms of safety, what type of distraction concerns you more?						
Using cell phones, navigation systems and other advanced technologies while driving.	40% (275)	38% (15)	50% (18)	41% (11)	40% (44)	40% (363)
Doing other activities while driving (e.g., eating, drinking, etc.)	11% (73)	18% (7)	6% (2)	0% (0)	12% (13)	10% (95)
Both are equally concerning	50% (347)	45% (18)	44% (16)	59% (16)	48% (53)	50% (450)
Total	100% (695)	100% (40)	100% (36)	100% (27)	100% (110)	100% (908)
Have you ever witnessed, or experienced a close call or crash resulting from a driver using a cellular phone or from your personal use with a cell phone?						
Witnessed/experienced a crash	15% (60)	13% (4)	7% (2)	35% (8)	16% (10)	16% (84)
Witnessed/experienced a close call	68% (266)	61% (19)	59% (16)	30% (7)	58% (36)	64% (344)
Never observed or experienced either	17% (68)	26% (8)	33% (9)	35% (8)	26% (16)	20% (109)
Total	100% (394)	100% (31)	100% (27)	100% (23)	100% (62)	100% (537)
How capable are drivers at making decisions about when it is safe to use technology while driving?						
Very capable	4% (20)	0% (0)	3% (1)	4% (1)	2% (2)	4% (24)
Reasonably capable	13% (65)	37% (14)	21% (6)	23% (6)	19% (15)	16% (106)
Drivers do a poor job	66% (319)	53% (20)	59% (17)	65% (17)	69% (56)	65% (429)
Drivers cannot make these judgements	16% (78)	11% (4)	17% (5)	8% (2)	10% (8)	15% (97)
Total	100% (482)	100% (38)	100% (29)	100% (26)	100% (81)	100% (656)
If purchasing an in-vehicle device, how much of an influence does the design and ease of use of devices have on your selection?						
Most important factor	29% (120)	41% (15)	26% (6)	39% (9)	40% (29)	32% (179)
Important, but tempered by other factors	49% (200)	54% (20)	70% (16)	57% (13)	36% (26)	48% (275)
Not particularly important	8% (32)	5% (2)	0% (0)	4% (1)	7% (5)	7% (40)
Not a consideration at all	15% (60)	0% (0)	4% (1)	0% (0)	18% (13)	13% (74)
Total	100% (412)	100% (37)	100% (23)	100% (23)	100% (73)	100% (568)

	Private Citizen	OEM/ Supplier	Academia/ Research Firm	Government	Other	TOTAL
Can auditory systems (devices with the capability to interpret voice commands, or communicate using speech messages) address the safety concerns associated with operating in-vehicle technologies?						
To a large extent	22% (136)	55% (22)	15% (5)	15% (4)	17% (18)	23% (185)
Only somewhat	33% (200)	30% (12)	48% (16)	42% (11)	36% (37)	34% (276)
Minimally	35% (215)	13% (5)	33% (11)	31% (8)	35% (36)	34% (275)
Don't know	10% (61)	3% (1)	3% (1)	12% (3)	13% (13)	10% (79)
Total	100% (612)	100% (40)	100% (33)	100% (26)	100% (104)	100% (815)
Do you believe hands-free technology is sufficient to address safety concerns related to cell phone use while driving?						
Yes	22% (84)	40% (12)	8% (2)	9% (2)	12% (7)	21% (107)
No	74% (281)	53% (16)	76% (19)	74% (17)	76% (45)	73% (378)
Don't know	4% (16)	7% (2)	16% (4)	17% (4)	12% (7)	6% (33)
Total	100% (381)	100% (30)	100% (25)	100% (23)	100% (59)	100% (518)
Is it possible to design electronic maps that can be safely used while driving?						
Yes	30% 134	68% 25	56% 14	42% 10	25% 19	33% 202
No	40% (182)	19% (7)	32% (8)	38% (9)	39% (30)	38% (236)
Don't know	30% (135)	14% (5)	12% (3)	21% (5)	36% (27)	29% (175)
Total	100% (451)	100% (37)	100% (25)	100% (24)	100% (76)	100% (613)
Is it possible to design wireless Internet devices (e.g., e-mail systems) that can be safely used while driving?						
Yes	17% (111)	49% (20)	31% (10)	32% (8)	16% (16)	19% (165)
No	69% (446)	32% (13)	53% (17)	48% (12)	62% (63)	65% (551)
Don't know	14% (92)	20% (8)	16% (5)	20% (5)	22% (22)	16% (132)
Total	100% (649)	100% (41)	100% (32)	100% (25)	100% (101)	100% (848)

	Private Citizen	OEM/ Supplier	Academia/ Research Firm	Government	Other	TOTAL
Should States or local governments enact laws to restrict the use of cell phones while driving?						
Yes	77% (516)	65% (26)	50% (16)	68% (19)	64% (67)	74% (644)
No	21% (138)	25% (10)	34% (11)	21% (6)	30% (31)	23% (196)
Don't know	2% (12)	10% (4)	16% (5)	11% (3)	7% (7)	4% (31)
Total	100% (666)	100% (40)	100% (32)	100% (28)	100% (105)	100% (871)
Can public education and training about the safe use of in-vehicle technologies (e.g., cell phones, navigation systems, etc.) increase safety?						
To a large extent	23% (147)	36% (15)	29% (10)	36% (9)	30% (31)	25% (212)
Only somewhat	31% (201)	31% (13)	37% (13)	36% (9)	30% (31)	31% (267)
Minimally	45% (294)	31% (13)	34% (12)	28% (7)	39% (40)	43% (366)
Don't know	2% (10)	2% (1)	0% (0)	0% (0)	0% (0)	1% (11)
Total	100% (652)	100% (42)	100% (35)	100% (25)	100% (102)	100% (856)
Have you changed how you use your cell phone in your vehicle because of a safety tip you saw or heard?						
Yes	37% (234)	48% (19)	36% (12)	42% (10)	43% (44)	38% (319)
No	23% (147)	40% (16)	18% (6)	38% (9)	31% (32)	25% (210)
Don't use a cell phone	40% (250)	13% (5)	45% (15)	21% (5)	25% (26)	36% (301)
Total	100% (631)	100% (40)	100% (33)	100% (24)	100% (102)	100% (830)
Is it safe to talk on a cell phone while driving?						
Yes	21% (170)	35% (16)	21% (9)	19% (6)	28% (37)	22% (238)
No	77% (628)	52% (24)	72% (31)	75% (24)	69% (91)	75% (798)
Don't know	2% (15)	13% (6)	7% (3)	6% (2)	3% (4)	3% (30)
Total	100% (813)	100% (46)	100% (43)	100% (32)	100% (132)	100% (1066)

	Private Citizen	OEM/ Supplier	Academia/ Research Firm	Government	Other	TOTAL
Which of the following is your biggest safety concern associated with cell phone use while driving?						
Dialing a telephone number	30% (220)	28% (13)	20% (8)	33% (10)	21% (26)	28% (277)
Answering the telephone	1% (10)	4% (2)	7% (3)	7% (2)	5% (6)	2% (23)
Holding a conversation	37% (272)	30% (14)	44% (18)	30% (9)	31% (38)	36% (351)
Doing cell-phone related tasks such as writing down notes while holding a conversation	33% (243)	37% (17)	29% (12)	30% (9)	43% (53)	34% (334)
Total	100% (745)	100% (46)	100% (41)	100% (30)	100% (123)	100% (985)
Under which conditions would you feel it safe to use a cell phone.						
Anytime while driving	8% (42)	10% (4)	3% (1)	4% (1)	5% (5)	7% (53)
When driving under light traffic conditions (on open road conditions)	23% (124)	63% (26)	58% (19)	44% (12)	32% (30)	29% (211)
It's never safe to use a cell phone while driving	69% (369)	27% (11)	39% (13)	52% (14)	63% (59)	64% (466)
Total	100% (535)	100% (41)	100% (33)	100% (27)	100% (94)	100% (730)
Do you use a hands-free or hand-held cell phone while driving?						
Yes, hands free	10% (42)	15% (5)	7% (2)	4% (1)	15% (10)	11% (60)
Yes, hand-held	14% (60)	38% (13)	23% (7)	40% (10)	26% (18)	19% (108)
Both, hands-free and hand-held	7% (29)	15% (5)	3% (1)	8% (2)	9% (6)	8% (43)
Own, but don't use while driving	32% (132)	18% (6)	23% (7)	16% (4)	26% (18)	29% (167)
Don't own	36% (151)	15% (5)	43% (13)	32% (8)	24% (16)	34% (193)
Total	100% (414)	100% (34)	100% (30)	100% (25)	100% (68)	100% (571)
If you use a "hands free" phone while driving, how often do you use it in your vehicle in its hands free mode?						
Frequently	18% (42)	39% (7)	6% (1)	0% (0)	24% (9)	18% (59)
Sometimes	5% (12)	11% (2)	24% (4)	17% (2)	11% (4)	8% (24)
Rarely	9% (20)	33% (6)	0% (0)	25% (3)	8% (3)	10% (32)
Do not use while driving	69% (161)	17% (3)	71% (12)	58% (7)	57% (21)	64% (204)
Total	100% (235)	100% (18)	100% (17)	100% (12)	100% (37)	100% (319)

	Private Citizen	OEM/ Supplier	Academia/ Research Firm	Government	Other	TOTAL
How often do you receive calls when you drive?						
Frequently	8% (28)	13% (4)	0% (0)	14% (3)	12% (7)	9% (42)
Sometimes	16% (56)	30% (9)	14% (3)	14% (3)	24% (14)	18% (85)
Rarely	29% (101)	50% (15)	52% (11)	45% (10)	29% (17)	32% (154)
Never	47% (164)	7% (2)	33% (7)	27% (6)	34% (20)	41% (199)
Total	100% (349)	100% (30)	100% (21)	100% (22)	100% (58)	100% (480)
For navigation systems, how important a feature is the capability to view maps while driving (when the vehicle is in motion)?						
Very important, wouldn't buy a system without this capability	12% (54)	46% (17)	24% (6)	14% (3)	13% (10)	15% (90)
Somewhat important, but not critical	11% (47)	16% (6)	16% (4)	9% (2)	8% (6)	11% (65)
Not important as long as turn-by-turn directions were provided	46% (202)	38% (14)	52% (13)	59% (13)	43% (33)	46% (275)
Don't know	31% (134)	0% (0)	8% (2)	18% (4)	36% (28)	28% (168)
Total	100% (437)	100% (37)	100% (25)	100% (22)	100% (77)	100% (598)
Would you purchase a system that prevents you from entering a destination address while the vehicle is in motion?						
Yes	67% (236)	45% (13)	71% (17)	68% (13)	64% (34)	65% (313)
No	33% (118)	55% (16)	29% (7)	32% (6)	36% (19)	35% (166)
Total	100% (354)	100% (29)	100% (24)	100% (19)	100% (53)	100% (479)
Have you ever witnessed, or experienced a close call or crash resulting from a driver being distracted by something other than a cell phone? (e.g. reading a map, eating, personal grooming)						
Witnessed/experienced a crash	22% (122)	19% (7)	32% (8)	40% (8)	27% (25)	23% (170)
Witnessed/experienced a close call	56% (313)	53% (19)	44% (11)	40% (8)	57% (53)	55% (404)
Never observed or experienced either	21% (119)	28% (10)	24% (6)	20% (4)	16% (15)	21% (154)
Total	100% (554)	100% (36)	100% (25)	100% (20)	100% (93)	100% (728)

	Private Citizen	OEM/ Supplier	Academia/ Research Firm	Government	Other	TOTAL
In your opinion, would a night vision system (designed to display distant objects on a head-up display low on the windshield) improve safety or pose a threat to safety by distracting drivers?						
Increase safety	35% (52)	50% (8)	29% (4)	57% (4)	48% (13)	38% (81)
No effect	3% (5)	6% (1)	14% (2)	14% (1)	7% (2)	5% (11)
Decrease safety	25% (37)	25% (4)	36% (5)	0% (0)	7% (2)	23% (48)
Don't know	36% (53)	19% (3)	21% (3)	29% (2)	37% (10)	34% (71)
Total	100% (147)	100% (16)	100% (14)	100% (7)	100% (27)	100% (211)

APPENDIX C:
“ASK THE EXPERT” PANEL QUESTIONS AND RESPONSES

Q. In your opinion, what is the single most important measure for understanding driver distraction? Why? (8/7/00 8:05:29 AM)

(Answered by Barry Kantowitz, UMTRI)

A. There are some general principles that apply to the selection of any measure for human factors research. This section is based upon an article in the journal Human Factors (Kantowitz, 1992) that offers a technical discussion of this issue. I have tried to simplify this discussion here.

In all science, measurement is the process of assigning numbers to objects in a systematic manner. The scientist interested in measurement must always answer two questions:

1. Representation problem. How is the assignment of numbers to objects justified?
2. Uniqueness problem. To what degree is this assignment unique?

Reliability is an index of the consistency of a measure and addresses the representation problem. Validity is an index of the truth of a measure and is related to the uniqueness problem. Good measures are both reliable and valid.

Good research must also be generalizable. This means that results can correctly be applied to real-world systems. Generalizability depends upon three factors: subject representativeness, variable representativeness, and setting representativeness (see Kantowitz, 1992 for detailed explanations of these terms.) We can't guarantee that a measure, even if reliable and valid, will work properly unless it is observed in a research setting that is generalizable.

Without getting bogged down in technical details (see Kantowitz, 1992 if you want to slog through details), the best way to select a measure that will work is to be guided by theory. It is poor science to select a measure just because it is easy to obtain. It is almost impossible to select a single measure that captures all the essential characteristics of a complex system, such as a driver in a vehicle. Theory must be used to select a set of measures that are useful and appropriate.

Selecting Measures for Driver Distraction

It might seem that the best way to measure driver distraction would be simply to ask drivers if they were distracted by some event. This is called obtaining a subjective opinion. We can make this process appear even more scientific by asking the driver to rate (perhaps on a five-point scale from 1-5) how distracted they were. This is called a rating scale. Unfortunately, people are not always able to give subjective ratings in a consistent manner (see Nygren, 1991). Even with a lot of fancy statistical treatments, it can be difficult to interpret subjective ratings. They are used because they are easy to obtain and because sometimes they can be correlated with better measures of distraction.

The best measures are objective rather than subjective. This includes measures of how the vehicle is located on the roadway, how hard the driver is pushing on the brake pedal, and how long it takes the driver to react to a signal. Physiological measures are also objective but they are best for determining long-term states of the driver, such as fatigue, rather than specific reactions to particular signals.

Since distractions are related to driver attention, theories of attention can help us select the best measures. An important class of measures require the driver to perform another task, called a secondary task, while driving (Kantowitz & Simsek, 2000). If the driver is distracted, there is less attention available to perform the secondary task. So objective performance on the secondary task can be interpreted, using a theory or model of attention, as an index of driver distraction. For example, a secondary task might require a driver to push a button on the steering wheel when an auditory tone is heard inside the vehicle. The time from the onset of this tone until the driver pushes the button, called reaction time, would be a measure of distraction. If reaction time is high, the driver was distracted when the tone came on. If reaction time is low with a rapid response to the tone, we can rule out distraction.

However, there is no unique secondary task for measuring driver distraction. Many secondary tasks have been studied and several are useful (Kantowitz & Simsek, 2000). Some typical secondary tasks would include memorizing telephone numbers, doing mental arithmetic and pressing buttons when signals are presented inside the vehicle. But most of these secondary tasks are scored either by reaction time or by proportion of correct responses. So the best measures of driver distraction are time and/or correct responses provided a secondary task has been selected that meets the criteria explained in the first section of this answer.

Conclusion
There is no single best measure of driver distraction. Objective measures are better than subjective measures. Secondary-task measures of driver distraction offer the best opportunity for success because they can be related to theories of attention. Even so, it is not simple to select the most appropriate secondary task.

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Nygren, T.E. (1991) Psychometric properties of subjective workload measurement techniques: Implications for their use in the assessment of perceived mental workload. Human Factors, 33, 17-34.

Q. What is the percentage of "driver distraction-caused" traffic accidents in the USA? Of these, what proportion are related to use of various in-vehicle technologies? What comparable estimates are available from other countries? What is the magnitude of off-setting benefits of in-vehicle, distraction-related technologies?

(Answered by Frances Bents, Dynamic Sciences, Inc.)

A. The Indiana based, "Tri-Level Study of the Causes of Traffic Accidents" published by NHTSA in 1975 remains one of the classic works in attempting to define causal factors in crashes. It tells us that about 90% of crashes include human factors as direct causes. Of these, approximately 50% were characterized as recognition errors, 40% as decision errors, and 10% as performance errors. These factors were derived from detailed analyses of crashes investigated by police and by trained in-depth crash investigators. Analysts were drawn from several disciplines. To my knowledge, the level of detail captured in this study has never been replicated.

Unfortunately, the Tri-level Study was conducted long before the current plethora of in-vehicle technologies were developed. Still, the report cites driver inattention, internal distraction, improper lookout and excessive speed among the most prevalent causal factors.
The more recent 1997 NHTSA report, "An Investigation of the Safety Implications of Wireless Communications in Vehicles" examines current databases for indications of technology-use based causal factors in crashes. As explained in my testimony at the Public Meeting, these databases rely heavily on police accident reports to recognize the use of cell phones (and other devices) as pre-crash factors. Given the widespread use of small, easily concealed, handheld phones, it is extremely difficult for law enforcement personnel to detect such use in the absence of witness statements or other physical evidence. Because cell phone use is not illegal, there is little incentive for officers to inquire about, or to note such use on their reports. The introduction of other devices such as fax machines and navigational aids is so recent, that a body of data (even of poor data) has not yet been developed.

Police reports will never be able to adequately assess technology use as a causal factor. Highway safety researchers face the same challenges, and generally conduct their investigations days after the crashes occur. A crash investigation-generated statistical basis for safety decisions regarding in-vehicle devices will always be lacking the required rigor. None of the other nations which have passed laws regulating the use of in-vehicle technologies did so on the basis of statistics.
For those few crashes in the FARS and NASS data for 1996-1997 which were determined to be technology related, the citations issued to recognized cell phone-using drivers were primarily for inattention, failure to yield, run off the road, and excessive speed. For the in-depth investigations conducted by Dynamic Science in support of the report, the overriding factor was driver inattention.

Clearly then, driver inattention is a recognized and significant factor in highway crashes. The question then becomes, "What causes driver inattention?" Any driver can tell you that there are many causes - roadside activities, crying children, handling CDs, eating, drinking, shaving, whatever humans can invent.

Current NHTSA sponsored databases indicate that about 30% of crashes are caused by driver distraction. I am not familiar with comparable data from other countries, and refer you to the National Center for Statistics and Analysis and the Bureau of Transportation Statistics.
In Japan, a one-month study of cell phone use by drivers was conducted by police in June of 1996, prior to the adoption of their law banning hand held phone use. They studied 129 crashes and determined that drivers were generally dialing a phone or responding to a call at the times of their crashes. This would indicate that biomechanical distraction (handling the phone) is a serious issue in Japan. Both crash investigation and human factors data in the U.S. show that it is the cognitive distraction of being involved in conversation that constitutes the greatest risk for drivers.

The question of potential benefits of in-vehicle, distraction-related technologies is of great interest at this time. The cell phone industry and the law enforcement community tout the benefits of immediate emergency notifications. Such calls can and should be made from a stopped vehicle, which makes the issue of driver distraction a moot point. The human factors research cited in the 1997 report includes one study that indicated that conversation may help offset fatigue among professional truck drivers. It certainly can be argued that rest is the best cure for driver fatigue, and adding a recognized cognitive distraction to an impaired drowsy driving situation may be a poor solution. In fact, a great deal of attention is focused on fatigued commercial vehicle drivers, and I have not heard anyone suggest that we should issue cell phones to such drivers to improve their performance.

The merits of other in-vehicle technologies such as navigational devices, and night vision systems will have to be judged based upon human factors studies - at least for the short term. It takes years to be able to develop a statistically reliable crash data set for emerging technologies of any kind as we have seen from recent experience with air bags and antilock brakes. But the absence of statistics should never be used as an excuse for inaction when a problem has been recognized. Cell phones are not essential devices for driving. In fact, in my opinion, they are an unnecessary and dangerous source of driver distraction. Our first priority must always be safety. The design and development of new technologies must not be driven by profit, or even by convenience. The devices must be shown to at least not degrade driving performance if they cannot be shown to enhance driving safety.

Q. In evaluating the safety impacts of in-vehicle technologies, what are appropriate baseline or comparative tasks? (8/1/00 1:05:43 PM)

(Answered by Valerie Gawron, Veridian Engineering)

A. Safety impacts of in-vehicle technologies installed in passenger vehicles can best be inferred from the number of **near misses** recorded in an instrumented vehicle. The vehicle should be dedicated to the driver who is the subject for the evaluation and the vehicle should be used as this driver's primary vehicle (e.g., fleet or personal car). The number of near misses is collected using "black boxes" installed in vehicles with ITS. The black boxes record video and performance data based on "trigger criteria." An example of a trigger criterion is vehicle deceleration greater than 0.4 g. Triggers are analyzed to determine if a near miss really occurred and what caused it. Again, a before/after comparison is made. Based on previous data, the number of triggers per number of crashes is 1000/1. At least 30,000 vehicle miles traveled are needed to derive this estimate. Note vehicles usually travel about 1000 miles per month.

Alternatives to Near Misses: Braking Time & Unsafe Distances

If a long period of time is not practical for the evaluation, then a short duration on-road evaluation in an instrumented vehicle or a driving simulator could be used. The data from such an evaluation, however, include the effects of learning to use both the vehicle and the in-vehicle ITS, of being watched, and of performing contrived driving scenarios. For simulators, there are also fidelity issues to consider. Data from this method include: obstacle avoidance and lane maintenance. Obstacle avoidance is measured in two ways: braking time and occurrence of unsafe distances. Olson and Sivak (1986) measured the time from the first sighting of an obstacle until the accelerator was released and the driver contacted the brake. Their data were collected in an instrumented vehicle driven on a two-lane rural road. Drory (1985) used the same measure in a simulator to evaluate the effects of different types of secondary tasks. Burger, Smith, Queen, and Slack (1977) used the brake reaction time distance between the cohort vehicle and the subject driver's vehicle. In addition they also calculated the minimum area surrounding a vehicle that should have been clear of other vehicles at the initiation of a specific maneuver and through the completion of the maneuver. This measure is similar to near misses described previously. To simplify the analysis in a later study, Burger, Mulholland, Smith, Sharkey, and Bardales (1980) used 60-foot criterion for gaps during lane changes. More recently, Korteling (1994) used car-following performance distance. In a series of on-road tests at Veridian, vehicle decelerations greater than 0.4 g were used to indicate unsafe following behavior.

Measuring Lane Maintenance

The risk of lane infringement and run-off-the-road accidents has been inferred from lane exceedances. This measure has already been used to evaluate in-vehicle ITS. For example, based on findings in a study of the safety aspects of Cathode Ray Tube (CRT) touch panel controls in automobiles, Zwahlen, Adams, and DeBald (1988) stated, "the probabilities of lane exceedence during the operation of a CRT touch panel (driving at 40 mph, along a straight, level, smooth roadway; under ideal driving conditions) are 3% and 15% for lane widths of 12 feet and 10 feet, respectively, which are unacceptable from a driver safety point of view." Summala, Nieminen, and Punto (1996) used lane exceedances to evaluate location of a display in an automobile cockpit. Imbeau, Wierwille, Wolf, and Chun (1989) reported that the variance of lane deviation increased if drivers performed a display reading task. The data from both these studies were collected in a driving simulator. A similar measure, Time-to-Line-Crossing (TLC), was developed to enhance preview-predictor models of human driving performance. TLC equals the time for the vehicle to reach either edge of the driving lane. It is calculated from lateral lane position, the heading angle, vehicle speed, and commanded steering angle (Godthelp, Milgram, and Blaauw, 1984). Godthelp (1986) reported, based on field study data, that TLC described anticipatory steering action during curve driving.

Eye Glance Measures

When data can be collected in only a single car and only on the driver (not the vehicle), glance behavior has been used to infer safety impacts. Glance duration has long been used to evaluate driver performance. For example, in an early study, Mourant and Rockwell (1970) analyzed the glance behavior of eight drivers traveling at 50 mph on an expressway. As the route became more familiar, drivers increased glances to the right edge marker and horizon. While following a car, drivers glanced more often at lane markers. Burger, Beggs, Smith, and Wulfeck (1974) discussed the importance of considering long-duration glances away from the forward scene during safety evaluations and suggested using 2.00 sec as the definition of a long-duration glance. In research more relevant to evaluating the safety impacts of in-vehicle systems, Zwahlen, Adams, and DeBald (1988), cited previously, investigated the eye scanning behavior when driving in a straight path while operating a simulated CRT touch panel display (radio and climate controls). Similarly, Imbeau, Wierwille, Wolf, and Chun (1989), also cited previously, used time glancing at a display to evaluate instrument panel lighting in automobiles. Not unexpectedly, higher complexity messages were associated with significantly longer (+0.05s more) glance times. Kurokawa and Wierwille (1991) found, in a study of control label abbreviation effects, that labels could produce small but reliable reductions in number of glances to the instrument panel. Fairclough, Ashby, and Parkes (1993) used glance duration to calculate the percentage of time that drivers looked at navigation information (a paper map versus an LCD text display), roadway ahead, rear view mirror, dashboard, left-wing mirror, right-wing mirror, left window, and right window. Data were collected in an instrumented vehicle driven on British roads. The authors concluded that this "measure proved sensitive enough to (a) differentiate between the paper map and the LCD/text display and (b) detect associated changes with regard to other areas of the visual scene" (p. 248). These authors warned, however, that reduction in glance durations might reflect the drivers' strategy to cope with the amount and legibility of the paper map. These authors also used glance duration and frequency to compare two in-vehicle route guidance systems. The data were collected from 23 subjects driving an instrumented vehicle in Germany. The data indicate, "as glance frequency to the navigation display increases, the number of glances to the dashboard, rear-view mirror and the left-wing mirror all show a significant decrease" (p. 251). Based on these results, the authors concluded, "Glance duration appears to be more sensitive to the difficulty of information update. Glance frequency represents the amount of. "Visual checking behavior" (p. 251).

Differences Between Simulator and On-Road Driver Performance

Olson and Sivak (1984), cited previously, used both laboratory and field studies to evaluate the effects of glare from rearview mirrors on driver performance. The laboratory study implied a reduction in seeing distance of 50% but, in the field study, the loss even at the highest glare level was only 15%. Korteling (1990) used the RT of correct responses and error percentages to compare laboratory, stationary, and on-road driving performance. RTs were significantly longer in on-road driving than in the laboratory.

Summary

If near misses cannot be collected then the following measures have been used to infer safety impact: braking time, distance to following vehicle, distance to obstacle, vehicle deceleration, probability of lane exceedence, and glance duration. If comparative data (i.e., in-vehicle ITS present versus absent) cannot be collected, then the following criteria have been used to infer safety impact:

- Braking time less than the time required to brake prior to hitting the obstacle
- Distance to following vehicle, less than braking distance
- Distance to obstacle, less than braking distance
- Vehicle deceleration, greater than 0.4 g
- Probability of lane exceedence, less than 3% for 12 foot lane and 15% for 10 foot lane
- Glance duration, less than or equal to 2 seconds

(Answered by Valerie Gawron, Veridian Engineering)

Q. What impact has cell phone use in Japan had on accident rates, and what steps, if any, has the government taken to improve safety? (7/31/00 6:33:42 AM)

(Answered by Hiroshi Tsuda, Nissan)

A. In Japan, the accident rate has increased with the proliferation of cell phones. In 1996, the Japanese National Police Agency conducted a nation-wide one month survey of all "Police reported" and "injury related" accidents. The resulting accident ratio suggested that the most dangerous part of using cell phones was receiving the call. The next was in placing a call. In order to get more data, in both 1997 and 1998, there was a 6 month nation-wide survey, also for all "Police reported" and "injury related" accidents. The results were in line with previous studies, indicating that the highest number of accidents occurred when drivers were receiving calls (43.0%), followed by those occurring while making calls (22.9%). In this second survey, car phone-related traffic accidents were found to represent 0.34% of all accidents involving injuries (370,536 total cases).

As a result of these investigations, it was concluded that although talking on the phone still caused accidents, the majority were caused by trying to pick up the call and secondly trying to place a call. The risk would be greatly reduced if the phones were to be hands-free, so the National Police Agency decided to put a ban on using the phone (or any hand held transmission device) with the exception of hands-held phones. A very good article describing the National Police Agency's ban can be found at the following link (http://www.drivers.com/cgi-bin/go.cgi?type=ART&id=000000273&static=1)

An extensive campaign on national TV, radio and newspapers preceded the ban that began November 1999, so it is safe to assume that it would be difficult to make excuses as to not having known of such a ban. The National Police Agency did a survey for the first month (i.e.; November 1999) and compared this with the month before (October 1999) and the same month the year before when there was no ban in place. Results found that in the month after the revised Road Traffic Law went into effect, the number of traffic accidents caused by drivers using cellular phones that resulted in fatalities or injuries fell by about 75 percent. Another survey was conducted for the half year from November 1999 to May 2000 and compared that with the same period in the previous year. The agency revealed that in this first 6-month-period, when the use of cellular phone while driving was banned, the number of accidents involving the use of cellular phones decreased by 60%.

My guess is, not everyone changed over to a hands-free phone, although there was an increase in demand for these devices. My personal view for reasons that accidents went down are:

1. Since most drivers knew it was against the law to use a hand held phone, they just simply refrained or only used it in very restricted instances.
2. Knowing it was against the law, when they did use it, they used it very carefully, which helps a lot.
3. In reporting to police, excuses such as, "I was using the phone" no longer seemed appropriate.

I would view that in Japan, with the statistics as those in 1997 and 1998, the decrease in accident rate compared to before the ban will stabilize at around 40%. Of course, the statistics cited above apply to Japanese drivers, and since the traffic situation and the way phones are used in Japan and in the US is quite different, the same statistics may not generalize to the US.

Q. What revisions would NHTSA like to see made to SAE's so called "15 second rule" proposed recommended practice? (7/27/00 6:20:27 AM)

(Question submitted to Michael Goodman. Response prepared by Thomas Ranney, Transportation Research Center; and Elizabeth Mazzae, NHTSA)

A. NHTSA has in the past and will continue to support the development of recommended practices like the 15-second rule. NHTSA recognizes the considerable efforts of the SAE Safety and Human Factors Committee on the development of this recommended practice. Moreover, since the 15-second rule is currently under revision, it is unclear what the next version of the rule will contain. Most generally, NHTSA does not know what specific changes should be made to the 15-second rule. There are several reasons for this position. First, the revision to the rule must represent a compromise that will be agreeable to a strong majority of the committee charged with development of the recommended practice. NHTSA does not presume to know what changes will create the compromise that will be acceptable to the majority of committee members. Second, NHTSA believes that there is insufficient direct empirical evidence on which to make specific recommendations for revision to the most recent 15-second rule. Third, NHTSA is not sufficiently familiar with production procedures, which place constraints on the type of testing that can be done on a given in-vehicle technology. However, there are several changes to the rule that NHTSA believes may help improve the chances of developing a strong compromise. First, the most-recent version of the rule only applies to one type of system. Clearly, guidelines are needed to address other types of systems and it should be decided whether these needs can be addressed in a single rule or whether a set of rules is needed. NHTSA believes that care should be taken to ensure that the 15-second rule is not applied to systems to which it was not intended. Second, NHTSA believes that the static condition defined in the most recent version of the 15-second rule is misleading in that it may lead people to believe that drivers can safely take their eyes and attention away from the roadway for 15 seconds. NHTSA believes the rule should be changed in such a way as to eliminate any confusion about this misinterpretation. Additional suggestions based on research to assess the quality of the 15-second rule are presented in the NHTSA report titled, "Driver Distraction with Wireless Telecommunications and Route Guidance Systems" posted on NHTSA's web site at http://www-nrd.nhtsa.dot.gov/include/crash-avoidance/DriverDistraction/ .

Q. Please comment on this hypothesis. "A properly trained motorist is more likely to be concentrating on the act of driving than one who is poorly trained and has not developed proper driving habits. Such a motorist will be less susceptible to distractions while driving." Is this, in your opinion, a legitimate area for research? (7/25/00 8:56:18 AM)

(Answered by Loren Staplin, Scientex Corp.)

A. First, a working assumption: a 'properly-trained' driver is one who has learned strategic (trip planning), tactical (situational awareness), and operational (vehicle maneuvering) skills to criterion levels not attainable by a 'poorly-trained' (or untrained) driver.

Next, one's concentration on 'the act of driving,' as exemplified by where one directs one's attention, how quickly and appropriately one responds to safety threats, etc., can reasonably be expected to change with experience, as specific behaviors are reinforced in some situations but not in others. Slowing down and checking carefully to the sides as one approaches an intersection where sight distance is limited by a structure, vegetation, etc., is reinforced often enough so that this training lesson sticks. (The partial reinforcement schedule for such behavior in fact makes it extremely likely to persist, to the motorist's advantage.) An untrained driver who happens to behave in this manner is similarly reinforced, of course. Thus, to the extent that a novice driver is 'properly' trained, the initial months or years of driving should be characterized by superior allocation of attention (i.e., looking where you should, when you should) relative to an untrained driver who must (hopefully) learn the same lessons through trial and error.

The differences in how effectively drivers attend to potential hazards (as well as their susceptibility to distractions) as a function of training may not be so evident over time, however. Some hazards manifest themselves very infrequently, such as trains encountered at at-grade crossings. As a result, slowing down sufficiently to effectively check to the sides before crossing the tracks may be reinforced so rarely that the 'properly trained' driver behaves no more safely than the untrained driver after some time. This may not be exactly what the question implied, by "susceptibility to distractions," though.

On this score, it is important to remember that training can have a strong impact on what a driver CAN do, but does not necessarily determine what he WILL do. An individual who has received relatively more extensive driver training may be expected to more rapidly find, understand, and react appropriately to the most safety-critical information in a given situation than an untrained or poorly trained individual. Training teaches drivers what to expect in the way of potential hazards, so they may be anticipated and recognized sooner, and responded to more effectively. This gained efficiency in visual search, except in extremely high demand situations (e.g., high-speed, high-volume traffic; or adverse weather conditions), will result in 'spare capacity.'

That is, while the untrained (especially novice) motorist is likely to experience the driving task as sufficiently demanding that his or her full attention is required to perform it, the highly-trained driver will perceive the difficulty of the driving task as being easier-even routine--especially when driving on familiar routes. And with this perception that one's full attention is not necessary to meet the demands of the driving task, the susceptibility to distraction increases.

This does not suggest that training is unnecessary or counterproductive. With experience, the same perceptions of spare capacity evolve. And for novices, I would expect safety benefits of training--especially to the extent it is focused on the 'tactical' aspects of driving, situational awareness and hazard recognition--to be measurable for at least several years. But to reiterate, it is the pattern of reinforcement for everyday behavior that ultimately controls how often and to what a driver pays attention.

At the moment, what seems to me to be the most interesting research approach in this area would be a comparison of the attentional behaviors and hazard avoidance responses, obtained unobtrusively under completely naturalistic (on-road) driving conditions, between groups selected to permit study of the interactions between experience, amount/type of training, and functional ability level.

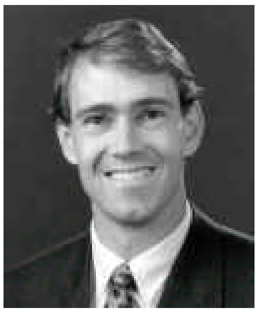
(Answered by Loren Staplin, Scientex Corp.)

Q. Figures that mobile phone use in cars involves a four-fold increase in crash risk are now commonly quoted. If this is true, where are all the crashes? There has been a massive increase in cell phone use in automobiles, but has there been a concomitant increase in crash rates? (7/24/00 7:19:12 AM)

(Answered by Michael Goodman, NHTSA)

A. The estimates to which you refer were made in an epidemiological study by a researcher at the University of Toronto. This study was able to examine crashes in detail, and by obtaining cell phone records, was able to draw an "association" between the use of the cell phone and the crash. While causality could not be established by this approach, the relationships were strong and was the basis for establishing the increase in crash risk for both hand-held and hands-free phones. Note also that the lack of crash data does not mean there is not a problem. The data does not exist because it is not collected by the state authorities. This situation may soon change as the various jurisdictions examine the issue more closely. You should also note that other research has consistently shown the relationship between wireless phone use and a deterioration in safety relevant driving performance. I would suggest that you read some of the research papers that are included on the web site.

Q. Would not the universal application of speech recognition technology allow the safe dialing of numbers via cell phone while driving? 7/21/00 7:24:35 AM



(Answered by John Lee, University of Iowa)

A. Short answer: Speech recognition technology could greatly reduce, but not completely eliminate, distractions that may make dialing a telephone while driving unsafe. Universal application of speech recognition technology may even have the counter-intuitive effect of degrading overall driving safety by encouraging more people to place calls while driving.

Long answer: Speech recognition would reduce the manual and visual distractions associated with dialing a cellular telephone. It would allow drivers to keep their hands on the wheel and eyes on the road; however, it would not eliminate the cognitive distractions. Telephone conversations with hands-free phones demand driver attention, particularly complex conversations. Similarly, interacting with a speech-based operating system can increase driver reaction times to roadway events. Because the commands to dial a phone are not complicated the cognitive distractions might be minimal, but speech-recognition in an automotive environment may be prone to errors and recovering from these errors could draw drivers attention away from the road. In addition, even a perfect speech recognition system might distract drivers if the dialog structure is not well-designed. A poorly designed dialing system could lead the driver to make errors and recovering from these errors could pose a cognitive distraction.

Other considerations (an even longer answer): The question implies that if the distractions associated with dialing a telephone were eliminated then the use of a cellular telephone while driving would be safe or at least appreciably safer than using a standard cellular telephone while driving. Completely eliminating the distractions associated with dialing might not affect the overall safety consequences of using a cellular telephone. Several studies suggest that the primary distraction associated with cellular telephones is the conversation and not the dialing.

Because speech recognition technology makes cellular telephone use SEEM much less distracting than manually pushing the buttons, it may encourage people to make calls that they wouldn't otherwise make. This would lead to more telephone calls and increase the total potential for distraction, even though the speech recognition technology might reduce the distraction associated with placing each call.

Thinking beyond the ability of speech recognition technology to dial the number, developers may take advantage of this technology and introduce a range of features that could be substantially more distracting. With speech recognition, it would be possible to allow the driver to search for numbers using an electronic "yellow pages". It would also be possible to allow drivers to search through electronic business cards to find a number. These features might encourage drivers to do things they would be unlikely to do (hopefully) with a standard cellular telephone, but that could be very distracting even with speech recognition.

Speech recognition technology may slightly decrease the overall distraction associated with cellular telephones by making dialing the telephone less distracting, but it may also encourage drivers to place more calls and may lead to new functionality that could be quite distracting. Unless properly implemented speech-recognition technology may have the counter-intuitive effect of increasing driver distraction and degrading driving safety.

Q. What role can automation play in reducing the driver distraction problem? What automated or assistance systems can we expect to see in the future? (7/20/00 7:47:20 AM)

(Answered by Steven Shladover. California

A.The relationship between driver distraction and automation is complicated and needs to be considered in several parts, because the effects are likely to be quite different:

- automation systems that can augment the driver's driving activities by providing additional "eyes and ears";
- automation systems that can partially substitute for the driver's driving activities;
- automation systems that can completely replace the driver's driving activities.

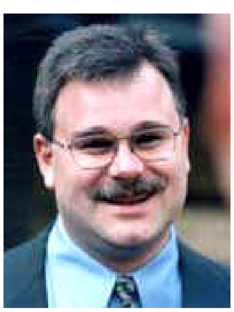
The first category of automation systems represent collision or safety warning systems, using sensors to detect hazardous driving conditions and then processing the sensor outputs to determine when the driver needs to be warned. The warnings could be auditory (tones, buzzers, synthesized speech), haptic (vibration or torque applied to steering wheel, vibration or pressure to gas pedal or seat cushion), kinesthetic (application of brake pulse) or visual (lights on instrument panel, in mirrors or head-up display). The auditory, haptic and kinesthetic warnings could be very effective at catching the attention of a distracted driver IF they are well designed to elicit the "correct" emergency response from the driver. The visual warnings are less likely to help, since the distracted driver is not necessarily going to notice them.

A variety of these systems have been introduced to the market for commercial trucks and buses in the U.S., to help avoid forward collisions, run-off-the-road crashes and side collisions during lane changes. However, the passenger car market has not yet seen any of these (except for short-range warnings to assist in parking, which are not really relevant to the driver distraction issue). A few such systems have recently been introduced in high-end cars in Japan.

The second category of systems, providing control assistance to the driver, present a more complicated picture relative to driver distraction. The most prominent of these systems is adaptive cruise control (ACC), which uses a forward ranging sensor such as a radar to measure the distance and closing rate to the leading vehicle and then uses that information to adjust the speed of the equipped vehicle so that it maintains an "appropriate" separation behind the leading vehicle. Another system that has been proposed by some people is a lane keeping assistance system, which would provide an active torque to the steering wheel to tend to keep the vehicle centered in the lane, providing the driver the impression of driving in gentle ruts in the pavement. The ACC systems may be able to improve safety by encouraging drivers to follow at somewhat longer separations from other vehicles than they do today, and they may be able to reduce rear-end crashes caused by inattentive drivers overtaking slower vehicles. However, if drivers become overly reliant on the ACC and do not really understand its limitations (inability to sense stopped vehicles, road debris, and animal intrusions and inability to respond to aggressive cut-ins or abrupt stops of preceding vehicles), it has the potential to exacerbate the driver distraction problem. This could even encourage drivers to engage in more non-driving tasks than they do now while driving, which would be most unfortunate. I am not aware of any definitive data to confirm or refute these hypotheses, which are in urgent need of testing by drivers who do not know that they are being tested for these issues. Primitive ACC systems have been on the passenger car market in Japan for several years, while capable ACC systems were introduced in Europe last year and are likely to be available in the U.S. within the next year on select high-end cars and heavy trucks. The lane keeping assistance systems would pose substantially more serious concerns for driver distraction and are not under serious consideration as products at this time, as far as I can tell. Any attempt to combine lane keeping assistance with ACC has the potential to be disastrous, because it would present the driver with a simulacrum of automated driving, which some drivers would be tempted to abuse by ignoring their driving responsibilities.

The third category of automation systems, which completely take over the driving function, raise an additional set of issues. These systems are not subject to distraction themselves, so while they are in use the driver distraction problem per se becomes a moot issue. The driver can turn his/her attention to other issues, or "tune out" completely, without raising safety concerns. However, the important issue then becomes how to re-engage the driver's attention at the end of the automated drive so that s/he can take over driving from the exit of the automated highway facility to his/her final destination. There are also some longer-term challenges associated with the possible decrement of driving skills or driving attentiveness by drivers who do a large fraction of their travel in the automated mode, but still need to do considerable conventional driving. It is important that they not carry over their expectations for performing other activities during the automated drive into their conventional manual driving behavior. The fully automated driving capabilities are likely to become available only to transit bus and commercial truck drivers on specially equipped facilities within the coming decade; passenger car drivers will probably need to wait until the decade after.

Q. In your opinion, what is the maximum number of recommended information displays a HUD should feature? Can you specify related references? (7/19/00 4:11:36 PM)



(Answered by Daniel McGehee, University of Iowa)

A. This is a very complicated question that is easily several dissertations worth of information. I will try to address these questions briefly and provide additional references that you can explore offline.

Your first question on the maximum number of recommended information displays a HUD should feature can be answered simply: It depends. There is a tendency for designers to think of such displays as a panacea. That is, since it intuitively seems that providing head-up information is best, then everything should be displayed using a head-up presentation. One comprehensive source on guidelines for automotive HUD information content is a PhD dissertation by Steve Jahns at the University of Iowa (Steven K. Jahns, 1996. Information content and format recommendations for automotive head-up displays, PhD Dissertation. University of Iowa). The guidelines cited in David Curry's response to this same question are based on Jahns' work.

It is my personal opinion that if HUDs are used, they are best suited to display simple command information (e.g., turn-by-turn information for navigation). More complex information (such as a detailed map) can be more distracting than a head down display. Drivers also may feel over-confident in their glances to a HUD versus a dedicated head-down display (HDD). For instance drivers know that is dangerous to look away from the roadway when they look at a HDD, however, drivers may feel that a HUD is safer to look at even the information may be equally as demanding. Other status-based information is simply not important enough to require head-up presentation. For instance, a glance to the speedometer is a common occurrence, but not necessary a visually demanding task. Other driver status information such as telltales also are not critical enough for this type of display and may be more salient if flashed on the instrument panel. Unlike commercial and military aircraft, drivers need not react immediately to this type of information. The use of HUDs for crash avoidance information may also may be a detriment since the goal of crash warnings are to immediately orient the driver's attention to the hazard.

Some other issues to consider before selecting a HUD as an information source include:

- Ambient light - Most drivers spend much of their time on-the-road during the day under high ambient light conditions. Cost limitations on current HUDs prevent salient information presentation during high ambient light conditions.
- Redundant information - Most, if not all information placed on HUDs in the past is redundant with the instrument panel. Designers need to consider the cost/benefit. Most HUDs to day are put on vehicles to increase the marketability of a vehicle.
- Perceptual capture- Although HUDs may be focused at a variety of distances in front of the vehicle, drivers still are required to perceptually capture the information, thus distracting them from the road (this is especially true for more attentionally demanding information). It is not possible to "look through the HUD" and see the environment ahead as well at the information display. We are "spot light" information processors-we are either looking at the HUD information or the outside environment. As a consequence, there are two distinct visual planes with HUDs and driving that independently require driver processing resources.

  A list of specific literature that takes into account (1) emerging technologies (2) cognitive load (3) the line of sight, and (4) driver preferences and adaptability to such a system can be found at the following link: www.uiowa.edu/~ppc/hudrefs.html

Q. The USA Today recently reported a story on cell phones and electronic driving distractions. The following statements, attributed to you, were cited in that article. "Glancing from the road to insert a compact disc, for example, makes a driver six times more likely to have an accident than glancing at the fuel gauge, says Tom Dingus, director of the Virginia Tech Transportation Institute. Programming some navigation systems while driving can increase the risk of an accident 30 times, Dingus says." Please explain. (7/14/00 10:06:46 AM)

(Answered by Thomas Dingus, Virginia Tech Transportation Institute)

A. Wierwille and Tijerina (1998) using a narrative crash database from North Carolina were able to put together a simple regression model that relates eye glance behavior to crash rates. This model, although simple, is built upon actual crash data and reasonable assumptions. The model requires as input the following parameters:

- Average Glance Length
- Number of Glances, and
- Frequency of device use

The data for the fuel gage was present in the Wierwille and Tijerina article as were data on the frequency of using radio controls. I used additional data that we have gathered on-road over several years from a variety of studies and data that were present in other articles to generate a range representing the types of new devices that are coming onto the market. In addition to using these data for glance length and number of glances, I estimated that a typical frequency of use for such a device would be 20 times per week. This represents two times per commute trip and would probably be a reasonable estimate for a navigation system with traffic information or a mobile internet type of application. In contrast, the radio control use frequency was 56 times per week. From these data, the model predicted a crash rate of 7 to 32 times higher for the newer devices relative to the simple visual task of checking a fuel gage.

Reference

Wierwille, W.W.and Tijerina, L. (l998). Modelling the Relationship between Driver In-Vehicle Visual Demands And Accident Occurrence. In Vision in Vehicles VI. North Holland Press, Amsterdam.

Q. In your opinion, what is the maximum number of recommended information displays a HUD should feature? (7/14/00 8:52:05 AM)

(Answered by David Curry, Delco Electronics Corporation)

A.Delphi uses the following guideline as to the amount of information to be displayed on a Head-Up Display (HUD).

- "To insure timely driver detection and response to the HUD information, the number of items on the HUD should be kept to a minimum by including only that information which is required or useful for a given set of circumstances.
- To ensure that the impact on driver task performance is minimized, no more than four to five efficiently designed

information items should be displayed on the HUD at any one time.
- If HUD information is only presented at very infrequent intervals (e.g., to indicate a system failure), the information may result in a prolonged "novelty" effect or a less than optimal driver response to HUD warning information. Provide enough HUD display information so that the driver is accustomed to scanning and responding to HUD information"

As a general rule, the greater the number of items on the display, the more distraction potential the display will have. During simulator experiments which we sponsored, drivers with 7 or 8 items on the HUD glanced at the display with increased frequency and duration in comparison to displays with fewer items. Their speed maintenance and lane position performance were also reduced while using high information complexity displays. Based upon these results, it is recommended that a maximum of four or five information items be presented on the HUD at any one time. This will eliminate overload potential by providing a cap in the complexity level the HUD can attain. Furthermore, an attempt should be made to keep the number of items on the HUD as low as possible at any one moment in time. Driver reaction to new information items will be best if such items are added to an uncluttered display (containing, for example, only one other item). If the driver has to detect a change in one of several items, reaction time will increase. Basically, this is an endorsement of "by-exception" type of HUD information---in other words, telltales may be displayed on the HUD for system malfunctions, but multiple status indicators (e.g., engine temperature, oil pressure, etc), for the most part, would not be appropriate unless they were out of tolerance. Notable exceptions to this heuristic would be such items of frequently accessed information as vehicle speed.

Note: Material for this response was gathered from guidelines prepared by Steve Jahns and Tom Dingus at the Human Factors Research Group at the Center for Computer-Aided Design at the University of Iowa under Delco Electronics sponsorship.

Q. How does crash risk change as a function of driver experience using car phones? Does risk drop or increase? Does this generalizes to other in-vehicle technologies? (7/10/00 12:54:04 PM)

(Answered by Frances Bents, Dynamic Sciences, Inc.)

A. To my knowledge, there is no crash investigation field data which has asked cell phone-using drivers involved in crashes about their related level of experience. Given the difficulties in trying to identify cell-phone use among crash involved drivers, it is not likely that reliable information regarding phone use behavior will be forthcoming.

We must then defer to human factors data. There are 3 types of distraction generally cited in the literature: visual, mechanical and cognitive.

It may be valid to assume that as cell phone users become more familiar with their equipment, they may spend less time looking at their device to turn on the power, or dial. They will still have to look at their phone if there are text messages, or other features. Therefore, there may be decreased *visual* distraction of a second or two for frequent users who can manually detect the power button and speed dial features.

With regard to mechanical distraction, the argument is that using a phone in a hands free mode (i.e., placing the phone in a holder of some sort) decreases driver distraction. The phone must still be dialed in some way, and calls sent out, but drivers would not be holding the phone to their ear. Frequent or casual cell phone users may decrease their *mechanical* distraction by using a holder, and keeping both hands on the wheel.

What seems to be most relevant to safe cell phone use is the *cognitive* distraction. I defer to the human factors experts who may have studied our ability to better multi-task as activities are practiced. But I would also caution that such practice would again more likely address the visual and mechanical aspects of cell phone use. Anyone of driving age has made numerous phone calls, using land lines, during their lifetimes. How do we respond to someone who is standing in front of us trying to capture our attention while we are on the phone? Often we wave them away, or interrupt our conversation on the phone to address the other person. Even after years of talking on the land line phone, our ability to concentrate on more than one activity doesn't seem to improve. The activity that cell phone using drivers are not attending to is the driving task. I believe that this is a critical issue, and that non-essential technologies which do not help us operate our vehicles more safely should not be allowed.

Q. Given that many in-vehicle technologies are now available and being used in Japan, what lessons can you offer to make these systems safer for drivers? (7/6/00 11:38:54 AM)

(Answered by Hiroshi Tsuda, Nissan)

A. Before giving my view regarding this, I would like to point out that there are differences between the two countries and that some aspects will not translate from one country to the other. In 1989, when the first "accurate-to-the-exact-street" navigation system for the Japanese market came out, there was much discussion as to how much information should be shown to the driver while the car was in motion. There was also concern over operation of the navigation system, such as inputting destinations. After much debate, it was decided that the major automotive OEMs would get together and conduct research to form the basis for common guidelines that would ensure good usable products while ensuring safety.

Reviews of previous research and follow up experiments with various systems and loads were conducted to come up with what is called the JAMA guidelines. (JAMA: Japanese Automobile Manufacturing Association.) The guidelines have undergone a couple of revisions as technology emerged, such as when communication of real-time traffic information became common.
I would not want to use the expression "learn", but rather address what is worth considering when developing and marketing such new in-vehicle systems. Below are personal views that I believe many of my colleagues share.

1. Human nature; Will the product (even if unintentionally) cause "human nature" to do what is not rationally safe? If the answer is yes, then consideration should be given as to how these systems are designed and marketed.

2. The Good and the BAD; Will the public benefit from these systems? If so, we should seek to ensure that the merits from these systems will be realized without getting overly cautious and killing the good in them. Therefore, guidelines must be practical. We cannot expect perfection.
3. Cooperation & Competition Without going against anti-trust issues, there should be good (honest) cooperation between OEMs so that logically and practically correct systems emerge and competition will be fought in areas where we will not sacrifice safety. Having certain restrictions will in many cases spawn new innovative design that are easier to use as well as being safer. This is healthy competition.
4. Timing is crucial. It is difficult to come to consensus once products come out in great numbers. After committing to a certain design, there could be a tendency for non-logical factors to dominate discussions. So it is better to come to a timely conclusion of a Grade-B solution rather than waiting forever for a Grade-A solution. In some cases, "Good is better than best, because best may never come."
5. Flexibility. Since technology evolves, we should be prepared to change guidelines to match these changes. There should be an institutional effort and climate that facilitates this making it possible to observe timing issues mentioned above (number 4).

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