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Driver Distraction: A Review of the Current State-of-Knowledge

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Distinct from other forms of driver inattention, distraction occurs when a driver's attention is diverted away from driving by a secondary task that requires focusing on an object, event, or person not related to the driving task. Although existing data is inadequate and not representative of the driving population, it is estimated that drivers engage in potentially distracting secondary tasks approximately 30 percent of the time their vehicles are in motion. Conversation with passengers is the most frequent secondary task followed by eating, smoking, manipulating controls, reaching inside the vehicle, and cell phone use. Driver attention status is unknown for a large percentage of crash-involved drivers in the Crashworthiness Data System (CDS). However for the period between 1995 and 2003 it is estimated that 10.5 percent of crash-involved drivers were distracted at the time of their crash involvement. Approximately 70 percent of distracted drivers' crashes were either non-collision (single-vehicle) or rear-end collisions. A significant proportion of the existing literature is devoted to assessing the impact of cell phone use on driving performance and safety. Although cell phone use represents a relatively small part of the overall distraction problem, use among drivers is steadily growing with approximately 10 percent of drivers using some type of cell phone at any point in time. Although not representative of the U.S. experience, the available evidence suggests that cell phone use increases drivers' crash risk by a factor of 4. Experimental studies consistently reveal driving performance degradation (primarily slowed response time) associated with cell phone use; however phone tasks used in these studies are generally unrealistic and often more complex than everyday phone conversations. Insufficient data exist to assess the distraction effects of in-vehicle information systems (IVIS), however experimental results suggest that voice-based interfaces are less distracting than those requiring manual entry (e.g., via keyboard). Standard behavioral countermeasures, including laws, enforcement, and sanctions, are considered unlikely to be effective because distraction is a broad societal problem associated with lifestyle patterns and choices. Options for environmental (roadway) strategies are limited. Considerable activity has been devoted to the development of guidelines for IVIS interface design, resulting in some improvements. Promising future developments include large-scale naturalistic data collections to provide objective and representative data on distraction incidence and crash risk, and advanced driver assistance technologies that monitor drivers' visual behavior and manage the flow of information to the driver. Recommendations for future research are presented.

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TABLE OF CONTENTS

1.0 INTRODUCTION

The increasing use of cellular phones has served as a catalyst for growing interest in driver distraction in recent years. While the use of cellular phones poses a significant and increasing risk to roadway safety (McCartt, Hellinga, & Braitman, 2006), studies show that it represents a relatively small proportion of a bigger distraction problem. At one extreme, distraction can be caused by everyday activities such as eating, smoking, and selecting radio stations. At the other extreme, distraction also results from drivers' interactions with advanced in-vehicle information systems (IVIS), which deliver traffic information and other forms of driver support. Accurate and timely traffic information can decrease travel times and costs as well as distraction if the driver does not have to divert attention to obtain the information. However, there exists the significant potential for distraction associated with these information systems. The responsibility for managing distraction is complicated by the fact that the capabilities of such systems appear independent of whether the systems exist as original equipment, add-on, or are brought into the vehicles by drivers. Indeed, Stutts et al. (2001) concluded that as the proliferation of wireless communication, entertainment and driver assistance systems continues, it is likely that the rate of distraction-related crashes will escalate.

The objective of this report is to consolidate current knowledge on driver distraction to help state and local governments formulate effective policies, regulations and laws. In addition, this report identifies areas in which scientific evidence is weak or lacking, thus providing information necessary to focus the Federal research effort in the most productive directions. The document begins by discussing the definition of distraction and the approaches and challenges involved in measuring distraction. Next, we consider the specific behaviors that comprise distraction and summarize what is known about their incidence and influence on crash involvement. This is followed by a discussion of the effects of cell phones on driving behavior and crash risk. We then consider in-vehicle technological advancements, such as navigation systems, and their potential for distraction. Next, we discuss the effectiveness of countermeasures that have been developed, including laws restricting cell phone use. Finally, we identify research needed to better understand and address the problem of driver distraction.

2.0 METHODOLOGICAL CONSIDERATIONS

Numerous research studies have addressed driver distraction. Most of these studies address issues relating to the distraction effects of cellular phones. The relevant literature has grown to the point that several comprehensive reviews have recently been published. One study (McCartt et al., 2006) reviewed 125 studies relating to cell phones and driving. For this report, we therefore use these secondary sources where possible, supplemented with primary sources where necessary for completeness.

2.1 Definitions of Distraction

Consolidating the existing knowledge about driver distraction runs into difficulty from the outset with the realization that there is no generally accepted definition of driver distraction (Trezise et al., 2006). The International Standards Organization developed the following rudimentary definition: Distraction is "attention given to a non-driving-related activity, typically to the detriment of driving performance" (Pettitt, Burnett, & Stevens, 2005). Stutts and colleagues distinguished distraction from other forms of driver inattention (Stutts, Reinfurt, Staplin, & Rodgman, 2001). They defined distraction as a form of inattention in which a driver "is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object, or person within or outside the vehicle compels or induces the driver's shifting attention away from the driving task."

Attempts to create a more comprehensive definition have focused on several issues. The first issue is whether driver distraction requires an identifiable source, including either an observable event (e.g., unexpected movement of an animal inside the vehicle) or an activity in which the driver chooses to engage (e.g., inserting a CD or eating). There is general agreement that the existence of a triggering activity is a critical part of the definition (Trezise et al., 2006; Pettitt et al., 2005); however, there is also a growing realization that "cognitive distraction" is a significant component of driver distraction (Young, Regan, & Hammer, 2003). Cognitive distraction refers to the mental workload associated with a task and is generally not observable. Moreover, one agency — The New Zealand Ministry of Transport — included "emotionally upset/preoccupied," among the categories of driver distraction.

A second issue concerns the question of how much control the driver has over the triggering activity. One analysis proposed three categories: (1) purposeful (e.g., inserting a CD); (2) incidental (e.g., answering a phone or eating); and (3) uncontrolled (e.g., movement of animal or child inside the vehicle) (Trezise et al., 2006). The distinction between the first two categories seems weak; however the importance of this dimension is underscored by one reporting authority's inclusion of sneezing/coughing/itching as a category of distraction. While it is generally agreed that activities in all three categories relate appropriately to driver distraction, inclusion of the latter group of involuntary responses seems beyond the focus of contemporary concern about driver distraction.

A third issue is whether distractions should include events or activities external to the vehicle as well as those inside the vehicle. Sudden, unexpected movements, for example by wild animals outside the vehicle, may be examples of external distractions. However, the inclusion of relatively common driving situations (e.g., driver blinded by sun or by oncoming headlights, sirens of police emergency vehicles) in one study seems inconsistent with the notion of distraction as involving unusual or unexpected events. In contrast, a potentially important source of distraction involves advertising signage, which is becoming both more prevalent and more dynamic and thus potentially more effective at capturing drivers' attention in certain areas (Wallace, 2003). Typically, categorizations allow external sources (e.g., "Outside person object or event") and it is generally found that these sources are associated with approximately 20 to 30 percent of the crashes caused by distraction. (Trezise et al., 2006)

Based on consideration of these issues, the Australian Road Safety Board (2006) presented the following comprehensive definition:

> Driver distraction is the voluntary or involuntary diversion of attention from the primary driving tasks not related to impairment (from alcohol, drugs, fatigue, or a medical condition) where the diversion occurs because the driver is performing an additional task (or tasks) and temporarily focusing on an object, event, or person not related to the primary driving tasks. The diversion reduces a driver's situational awareness, decision making, and/or performance resulting, in some instances, in a collision or near-miss or corrective action by the driver and/or other road user.

Restricting distraction to situations in which a secondary task, event, or object can be identified creates a clean boundary between this and other forms of inattention. This criterion thus serves to maximize the objectivity of reporting, which is essential given that the data sources are primarily administrative documents (e.g., police crash reports) rather than research-quality data. The main weakness of this definition is that it allows cognitive distraction only as part of the driver's performance of an identifiable secondary task and not alone (as in being lost in thought or emotionally upset). However, as detailed in the next section, data collection capabilities are expanding to the point that video data of drivers' pre-crash behaviors may soon be available. These data are expected to provide insights into the visual behaviors associated with episodes of cognitive distraction, which may facilitate a broadening of the definition of distraction to include some behaviors not associated with an identifiable secondary task.

2.2 Measurement of Driver Distraction

Distraction contributes to motor vehicle crashes when a driver's attention is diverted away from the driving task at a time when the driver is required to identify and respond to an unexpected hazard or a changing driving situation (e.g., lead vehicle braking). Distraction may also be associated with lapses of vehicle control, resulting in unintended speed changes or allowing the vehicle to drift outside the lane boundaries. Because of the significant difficulties inherent in measuring driver attention, the magnitude and particularly the safety implications of driver distraction have been very difficult to determine. Indeed, as pointed out by Stutts et al. (2005a), unlike seat belt use, the driver's attention status cannot be categorized as "yes" or "no," and it cannot be quantified in the same manner as blood alcohol level.

The effects of distraction have been measured in several types of studies, including:

- Observational studies;
- Crash-based studies; and
- Experimental studies of driving performance.

Observational studies provide direct information about the types and incidence of secondary tasks that drivers attempt while driving. Two types of observational studies have been conducted, including fixed-site observations and naturalistic in-vehicle observations. In the former, a stationary observer records the activities and demographic characteristics of drivers as they pass a selected location. The information obtained is limited by the time available and the fidelity of the discriminations that can be made by observers as vehicles move past a fixed location. In naturalistic studies, volunteer participants drive vehicles instrumented with sensors and video cameras, which allows driving behavior to be recorded at all times. Instrumentation is generally unobtrusive and does not damage the driver's vehicle when removed. Advances in data storage and remote communication technologies allow researchers to access vehicles infrequently and often remotely. A complete video record provides valid data concerning the incidence of potentially distracting activities in which the sampled drivers engage. These studies are limited by the possibility that drivers will not behave naturally if they know their vehicles are instrumented, as well as the relatively small samples of drivers who can be included due to the expense associated with instrumenting each vehicle. Another limitation is that the vast majority of everyday driving behavior is uneventful and thus the cost of continuously recording and examining all driver activity relative to the number of resulting crashes is high, given the low probability that a given driver will be involved in a crash in a given year. The result is that very large numbers of drivers are needed to obtain a useful number of crashes.

Crash-based studies provide the most direct information about the safety implications of performing secondary tasks. Unfortunately, it is very difficult to accurately determine whether driver distraction or any other form of inattention was a contributing factor in a crash. Investigating officers typically do not report the occurrence of a distracting activity unless there is direct evidence and drivers are understandably reluctant to admit that they were engaged in a secondary task, particularly if that involvement may have contributed to the crash. Therefore, it is generally thought that the incidence of distraction among crash-involved drivers is underestimated in crash studies (Trezise et al., 2006; Stutts et al., 2001; McCartt et al., 2006). Crash studies are also limited by the absence of matched exposure data, which are necessary to determine the relative crash risks associated with distracting secondary tasks. In the absence of exposure data, crash data analyses are limited to reporting the incidence of distracting activities among crash-involved drivers.

Thus, when crash and exposure data are used together, it is possible to determine which secondary activities are more likely to result in crashes. However, crash data alone provide no information about crash causation. Naturalistic observational studies offer the promise of providing both detailed crash and matched exposure data.

Experimental studies are conducted in controlled settings, including driving simulator laboratories and closed test tracks. The research methodologies are derived from laboratory studies of attention, which have demonstrated that certain combinations of tasks cannot be performed together without interference. This finding applies directly to driving. For example, secondary tasks that require drivers to look away from the roadway (e.g., to view a navigation map display) are likely to interfere with drivers' abilities to visually monitor the roadway ahead. Moreover, the effort devoted to interpreting the map display is likely to interfere with drivers' ability to interpret an emerging hazardous situation ahead. Because almost all secondary tasks involve some perceptual-cognitive components, it is likely that some interference with driving will be observed (Wickens, 1999).

Experimental studies measure the potential for distraction, which is a relative assessment of the level of primary-task (driving) degradation associated with a given secondary task. Participants are typically instructed concerning when and how often to engage in secondary tasks while driving. Experimental studies do not incorporate motivational factors that influence drivers' willingness to engage in secondary tasks in real-world driving. Experimental studies thus do not provide direct information about the real-world risk of a given secondary task, only the level of primary (driving) task degradation when performed in a given setting. The real-world risk associated with a secondary task relates to the priority given by the driver to this task and the driving situations in which the driver is willing to engage in the task.

Drivers' willingness to engage in secondary tasks is related to the benefits they associate with the secondary tasks. Secondary tasks may be perceived as beneficial because they provide entertainment, counteract the effects of boredom or fatigue, or because they allow the driver to accomplish "work," such as making business calls or scheduling appointments while driving. It is also likely that over time drivers become so accustomed to driving while performing secondary tasks (e.g., listening to the radio) that the combination of primary and secondary task becomes the rule rather than the exception.

Difficulties characterizing factors that contribute to drivers' willingness to engage in secondary tasks have raised questions about the ability to generalize experimental results to real-world driving. For example, two secondary tasks may be equivalent in their potential for distraction when tested using an experimental protocol in which task priorities are set and the driving task demands are fixed. However, if one task is perceived to be more essential to real-world users, this task will likely be performed more often while driving and in more-dangerous driving situations. The real-world result would be that the more essential task poses a significantly greater risk, even though the laboratory experiments found them to have equal potential for distraction.

A related obstacle to the measurement of distraction is that the level of distraction associated with a given secondary task depends on the extent to which a driver is engaged in the task. Consider the difference between a casual phone conversation and a complex conversation of significant importance to the driver. The latter will typically demand more concentration resulting in a higher level of engagement than the former. Factors such as engagement and concentration, while not observable, contribute to the level of cognitive distraction associated with a secondary task. Similarly, individual differences in drivers' abilities to switch between primary and secondary tasks, and other factors including intelligence, will determine how difficult a given task is for a given driver. Thus, a task may be relatively easy and less distracting for one individual than for another. These factors contribute to the difficulty of measuring distraction and are typically not addressed in experimental studies.

The measurement of distraction was the focus of several large scale research projects conducted by consortia of researchers, government agencies, and automotive manufacturers. The consortia include the recently completed European project HASTE (Human machine interface And the Safety of Traffic in Europe) (Carsten & Brookhuis, 2005a), the Driver Workload Metrics (DWM) Consortium of the Collision Avoidance Metrics Partnership (CAMP) (Angell et al., 2006) and the German Advanced Driver Attention Metrics (ADAM) program (Mattes, 2003). The projects adopted slightly different approaches and came to slightly different conclusions about how best to measure driver distraction.

The HASTE program was undertaken by eight European partners and Canada. The goal was to develop methodologies and guidelines for the assessment of In-Vehicle Information Systems (IVIS). Numerous experiments were conducted across Europe and Canada using a variety of test venues. HASTE researchers found differences between the testing venues. Specifically, they found that driving was degraded more on real roads than in simulators when drivers performed the same secondary tasks. They speculated that the relatively limited fidelity of existing simulators may have been the main reason for this discrepancy. However, emphasizing the efficiency and reproducibility of the assessment environment that can be obtained in driving simulators over the realism of real-road driving, they concluded that an assessment regime that uses a reasonably advanced driving simulator, incorporating scenarios that require rural road driving, can provide meaningful and potentially reliable results (Carsten et al., 2005a; Carsten et al., 2005b). They also concluded that between four and six behavioral parameters would be sufficient to evaluate any system offered for assessment.

One major finding of this work was that the effects of cognitive distraction differ considerably from those of visual distraction on driving performance. Secondary tasks that were mostly visual led to decrements in steering and lateral vehicle control. In contrast, secondary tasks that were mostly cognitive led to decrements in longitudinal vehicle control, particularly car-following (Carsten et al., 2005a). One apparently anomalous finding was that when secondary task cognitive demands increased, drivers' lateral control was found to improve. Analysis of drivers' eye glance patterns revealed that when cognitive demands increased, drivers increased their concentration on the road center and decreased looking at the periphery. Although the underlying behavioral mechanism is not well understood, it is thought that the increasing demands of the secondary task cause drivers to simplify their driving by focusing on what is immediately in front of them. The "improvement" in lateral control is thus an unintended consequence of this simplification as lateral vehicle control becomes guided by central rather than by peripheral vision. The cost to drivers is that they no longer have the ability to monitor their periphery and thus will not detect hazards until they are immediately in front of the vehicle. These results reveal the importance of analyzing drivers' eye glance patterns for understanding the attentional mechanisms involved in distraction.

The Driver Workload Metrics Project was conducted by the CAMP consortium, which included researchers from Ford, GM, Nissan, and Toyota. The main objective was to develop performance metrics and test procedures that could be used to assess how the distraction associated with an in-vehicle system might degrade or interfere with driving performance. They also sought to develop a toolkit of evaluation methods that would allow developers to minimize the workload implications of future in-vehicle systems during the design process. They conducted experiments in three test venues, including laboratory, test track, and on-road driving. Their focus was on the selection of driving performance metrics obtained in an experimental context that can be used to predict the safety implications of distraction in real driving.

Four categories of driving performance metrics were identified as having direct implications for safety. These included driver eye-glance patterns, lateral vehicle control, longitudinal vehicle control, and object-and-event detection. The researchers also identified a number of potential surrogates, which included laboratory measures, ratings, and analytical methods thought to have predictive values with respect to the above-mentioned performance measures. They performed a series of analyses to determine which of their performance metrics discriminated driving with a secondary task from driving alone. They also determined which metrics discriminated high- from low-workload secondary tasks. The majority of metrics that passed one or both of these tests were eye-glance measures. In addition, they found that measures generally discriminated high- from low-workload tasks much better for visual-manual than for auditory-vocal secondary tasks. Visual-manual tasks affected driving performance more than auditory-vocal tasks.

The main conclusion of the CAMP project was that the interference to driving caused by in-vehicle secondary tasks was multidimensional and no single metric could measure all effects. In agreement with the HASTE results, CAMP researchers found that visual-manual secondary tasks exhibited different performance profiles than auditory-vocal tasks. They concluded that eye-glance data contains important information for assessing the distraction effects of both auditory-vocal and visual-manual tasks. Based on the secondary tasks they used, they concluded that cognitive distraction plays a much smaller role than visual distraction. Finally, because they found some degradation in the laboratory that was not found in the driving behavior, they concluded that the laboratory results alone were not sufficient to assess the distraction potential associated with secondary tasks.

The ADAM project has focused on the development of a lane change task (LCT). This task requires drivers to respond to a sequence of lane-change assignments while performing secondary tasks (Mattes, 2003). The summary measure derived from the LCT has been shown to be sensitive to different types of secondary tasks and is being promoted as a standardized measure of distraction potential.

These projects were ambitious attempts to select driving performance metrics with some known relationship to on-road safety. However, as they progressed it became clear that it is virtually impossible to use experimental results to predict real-world risks associated with different secondary tasks. Thus, while the metrics identified in these studies may be very helpful for assessing the relative potential for distraction associated with in-vehicle systems during their development, the ultimate safety effects of new in-vehicle technologies cannot be known until the technologies are used in real-world driving, and data pertaining to drivers' willingness to engage in the secondary tasks are obtained.

3.0 INCIDENCE AND SAFETY CONSEQUENCES OF DISTRACTION

With these methodological considerations as background, we now consider what is known about the incidence of potentially distracting secondary tasks and their effects on safety. First, we summarize the results of observational studies that document the incidence of various secondary tasks. Next, we consider what is known about the involvement of distraction in crashes. We then discuss the strengths and weaknesses of naturalistic observational studies for providing detailed information about distracted driving and its consequences.

3.1 What Activities Comprise Distraction?

In 2001, the Highway Safety Research Center at the University of North Carolina conducted a "naturalistic" observational study to determine the types of activities drivers attempt while driving and their potential consequences (Stutts et al., 2005a). Seventy drivers drove their own vehicles for a week during which approximately 10 hours were video-recorded and analyzed to identify the incidence of various distracting secondary tasks. They found that drivers spent approximately 15.3 percent of the time the vehicles were moving engaged in conversation with passengers. Drivers engaged in some other activity 14.5 percent of the total driving time. Percentages of times for specific activities included: preparing to eat, eating or spilling (4.6%); reaching for something or leaning, plus other internal distractions (3.8%); cell phone use (including dialing, answering, and talking) (1.3%); manipulating audio controls (1.4%); and smoking (1.6%).

Sayer, Devonshire, and Flannagan (2005) observed samples of 5-second video clips obtained from 36 drivers during routine driving. Their analysis was based on approximately 120 hours of driving. They found that 34 percent of the 5-second episodes involved a secondary task. Most common was conversation with another passenger, which occurred in 15 percent of the samples, followed by grooming (6.5%), use of a hand-held cellular phone (5.3%), and eating or drinking (1.9%). They found that the occurrence of secondary-task engagement decreased with driver age. Samples taken from younger drivers (mean age 25) were more than twice as likely to involve secondary activities as were those of older drivers (mean age 64). For this study, drivers used borrowed vehicles, which were equipped with lane-departure warning systems as well as data acquisition instrumentation. Thus, the behavior observed was not fully natural.

These two studies are fairly consistent in their finding that drivers spend approximately 15 percent of their total driving time engaged in conversation with passengers and an approximately equal amount of time engaged in other identifiable activities.

3.2 Incidence of Distraction Among Crash-Involved Drivers

Using 1995-1999 Crashworthiness Data System (CDS) data, which only include crashes serious enough that one vehicle was towed from the scene, Stutts et al. (2001) reported that 8.3 percent of the crash-involved vehicles had distracted drivers. Driver attention status was not recorded for 36 percent of the drivers. If the distribution of driver attention status among the unknowns was similar to that for the known cases, then the incidence of distraction among drivers involved in crashes would increase from 8.3 percent to 12.9 percent. However, the evidence in support of this assumption is equivocal (Stutts et al., 2001). Therefore, if one adopts a more conservative assumption that the incidence of distraction among drivers with unknown attention status is half the incidence of distraction among drivers with known attention status, then the overall incidence of distraction among crash-involved drivers is approximately 10.6 percent. Stutts et al. (2005b) performed similar analyses using the 2000-2003 CDS data. They found that 6.6 percent of crash-involved drivers were distracted; however, the attention status was unknown for 46 percent of the drivers. If one applies the same conservative assumption concerning the incidence of distraction among the unknowns, the overall percentage of distracted crash-involved drivers becomes approximately 10.4 percent. Thus, while there are variations between years, it appears that over the period from 1995 to 2003, approximately 10.5 percent of drivers involved in crashes serious enough to require at least one vehicle to be towed from the scene were distracted at the time of their crash involvement. Moreover, the fact that the estimated percentages for the two data collection intervals are virtually identical indicates that there was no discernible increase in the percentage of distracted, crash-involved drivers over this period.

In the 1995-1999 analysis, approximately 70 percent of the reported distractions were inside the vehicle, with the remaining 30 percent occurring outside the vehicle. Passengers and audio devices were the most prevalent reported distractions. Among the specific sources cited in the 2000-2003 analysis were an outside object/person/event (23.7%) and another vehicle occupant (20.8%). These were followed by using or reaching for an object (5.2%), a moving object inside the vehicle (3.7%), cell phone (3.6%), adjusting radio/cassette/CD (2.9%), eating/drinking (2.8%), adjusting climate control (1.5%), and smoking (1%).

Contextual factors were found to be important in the earlier study. Specifically, Stutts et al. (2001) reported that crashes associated with adjusting audio devices were more likely at night, moving objects inside the vehicle were more likely on non-level grades, and distractions involving communication with other occupants were more likely at intersections. The later study included more detail on the circumstances and consequences of collisions involving driver distraction (Stutts et al., 2005b). Younger (under 20) and older (70+) crash-involved drivers were more likely than drivers of other ages to have been distracted at the time of their crashes (12 to 14 % versus 6 to 9%). Distracted drivers were 50 percent more likely to have been seriously injured or killed in their crashes, relative to attentive drivers. Distracted drivers were more likely than attentive drivers to have been involved in non-collision (i.e., single-vehicle) or rear-end crashes. Approximately 70 percent of the distracted driver crashes involved one of these two events, with the remainder being primarily angle collisions. Compared to the crashes of attentive drivers, the crashes of distracted drivers were more likely to occur during evening or nighttime hours and less likely to occur on high-speed roadways, multi-lane roadways, curves, and intersections. The analyses also revealed differences between collisions involving distracted drivers and those involving drivers with other forms of inattention. Specifically, 82 percent of the crashes involving inattentive drivers who “looked but did not see” were angle collisions, with the vast majority of these involving turns. Almost 78 percent of the crashes sustained by drowsy drivers were single-vehicle noncollision crashes. These differences underscore the importance of considering distraction as a distinct problem, different from other categories of inattention.

Naturalistic observational studies are emerging as one approach to solve the problem of determining exactly what the driver was doing immediately prior to a crash. Naturalistic studies also provide the potential for combining exposure data with crash data to allow computation of odds ratios or other measures of the relative crash risk associated with various secondary tasks. In the absence of large numbers of crashes, naturalistic studies have focused on the precursors of “near-crashes,” on the assumption that the types of precipitating errors, including the incidence of distraction, would be similar for near-crashes and crashes. However, this assumption has not been adequately validated.

One such study merits consideration (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). The 100-Car Naturalistic Driving Study was performed by Virginia Tech Transportation Institute (VTTI) for NHTSA. One hundred drivers who commuted into or around the northern Virginia/Washington, DC, metropolitan area were recruited. They used either their own vehicles or leased vehicles. The sample was restricted to six passenger vehicle types, due to instrumentation feasibility issues. The driver sample was selected to include disproportionate numbers of younger (18 to 25 years old) drivers and drivers with high annual mileage. This was intended to maximize the potential for recording crashes and near-crash events. Data were recorded over a 12- to 13-month period. In all, there were 2 million vehicle miles and approximately 43,000 hours of data from 241 drivers.

Data were obtained from 69 crashes, 761 near-crashes, and approximately 20,000 baseline segments, selected randomly to represent normal uneventful driving. Distraction due to a secondary task was reported in 33 percent of the crashes and 27 percent of the near crashes. Using the crash and near-crash data together with the baseline data, the authors computed odds ratios, which represent the relative risk associated with a given secondary task. They defined three categories of secondary tasks, based on the number of button presses and/or glances away from the forward road. Complex tasks required more than two button presses or eye-glances away from the road and included applying makeup, reaching for a moving object or hand-held device, and dialing a hand-held device. Moderate secondary tasks, defined as requiring at most two button presses or eye-glances, included talking or listening to a hand-held device, inserting a CD or cassette, or eating, among others. Simple tasks required at most one button press or eye glance and included adjusting the radio, drinking, or smoking. The odds ratios support the conclusion that secondary-task complexity, as defined above, influences crash and near-crash risk. Specifically, computed odds ratios were 3.1 for complex secondary tasks, 2.1 for moderate secondary tasks, and 1.0 for simple secondary tasks. This means that when performing a complex secondary task, drivers were exposed to approximately three times the risk of involvement in a crash or near-crash as were drivers who were not engaged in a secondary task. For moderate secondary tasks, there was approximately twice the risk as driving with no secondary task and for simple secondary tasks there was no appreciable increase in risk.

Additional analyses were conducted to identify the environmental conditions associated with distraction-related crashes and near-crashes. For these analyses, only the complex secondary tasks were associated with elevated odds ratios, indicative of elevated risk. Specifically, for drivers performing complex secondary tasks, elevated odds ratios were found for the following conditions: dusk and unlighted darkness, rain, divided roads, and roads with grades (straight or curved). Thus with the exception of divided roads, which are normally considered safer than undivided roads, the results support the conclusion that engaging in a complex secondary task is more likely to result in a crash or near-crash in relatively difficult driving situations.

There are several caveats that must be considered in the interpretation of this data. First, 90 percent of the outcome events were near-crashes, not crashes. Furthermore, the definition of a crash allowed inclusion of events that would not have reached the damage criterion for police reporting of crashes. Thus the elevated odds ratios indicate that drivers were more likely to be involved in relatively minor events, most of which did not result in a crash. Second, the inclusion of multiple crash or near-crash events from each driver creates statistical problems, which raise questions about how well the study results represent the experience of the driving population more generally. Third, the baseline samples were selected randomly and were thus not matched in terms of any descriptors (e.g., time of day, location, environmental conditions) to the crash or near-crash events. McCartt et al. (2006) concluded that naturalistic studies have the potential for providing useful data when adequate and representative samples of drivers are combined with exposure or control-group data. This potential was recognized by the Strategic Highway Research Program (SHRP II), which is planning to fund a naturalistic study of much larger scale than the 100-car study. It is expected that the data obtained in that study will be more representative of the entire country and will contain significantly larger numbers of crashes so that estimates of crash risk associated with various secondary tasks can be more precisely computed.

4.0 TECHNOLOGY-BASED DISTRACTIONS

4.1 Mobile Telephones

Cell phones are the contemporary icon of driver distraction. The fact that their use among drivers in the United States is steadily increasing has been demonstrated by four daylight surveys conducted by NHTSA (Glassbrenner, 2005a; Glassbrenner, 2005b; Glassbrenner, 2005c; Utter, 2001). According to these surveys, the incidence of handheld phone use among drivers has increased from 3 percent in 2002, to 4 percent in 2003, 5 percent in 2004, and 6 percent in 2005. In the most recent survey, there was wide variation among age groups, with 10 percent of 16- to 24-year-olds holding phones versus 1 percent of drivers over age 70. Females were more likely to be holding a phone (8% versus 5% for males). Using additional data, NHTSA estimated that in 2005 approximately 10 percent of drivers in a typical daytime moment were using some type of phone, whether hand-held or hands-free (Glassbrenner, 2005c). Roadside surveys conducted in the United Kingdom revealed that phone use declines with increasing age and, in contrast to the U.S. results, that men were slightly more likely to use phones than women (Trezise et al., 2006).

A considerable body of research has been published in an attempt to understand the effects of cellular phone use on driving behavior and safety as well as the effects of attempts to limit cellular phone use while driving. McCartt and colleagues (2006) have recently published a comprehensive review of this literature, in which they synthesized the results of 125 studies. Over 50 of these were experimental studies in which volunteer drivers were tested on driving simulators or instrumented vehicles on test tracks or public roads. According to their review, experimental studies typically find that performance on driving simulators in instrumented vehicles is compromised by tasks that attempt to replicate the demands of phone conversation. Slowed reaction time is the most consistent finding and degraded performance is more pronounced among older drivers (age 50 to 80) than among younger drivers. More difficult phone tasks, which may involve complex computational or recall tasks, produce greater performance decrements. McCartt et al. (2006) present some evidence that phone conversations are more disruptive than conversations with passengers or manipulating a radio, CD, or cassette player.

Despite the fact that the preponderance of experimental evidence consistently reveals driving performance degradation associated with phone use, McCartt et al. (2006) question the usefulness of the experimental data for assessing the safety implications of phone use while driving. They refer to a lack of "operational clarity," which refers to the difficulties involved in comparing results from studies that used different methods. This raises concerns about the reliability of the findings as well as their ecological validity, which refers to how well the experiments recreate the real-world challenges of phone use while driving. This area of research has been criticized for using artificial phone tasks and has had considerable difficulty characterizing the content and level of driver involvement in phone conversations. Clearly, the level of distraction and corresponding primary task degradation are likely to be much higher when a driver is heavily engaged in a meaningful, serious conversation than when engaged in a superficial meaningless conversation. The same is true for complex versus simple conversations. These two dimensions, the level of driver engagement and conversation complexity, combine to influence the amount of mental workload or effort that a driver devotes to a phone conversation while driving. This level of effort translates directly into the level of cognitive distraction. The inability to characterize the dynamics of naturalistic phone conversations is one problem that has raised concerns about the ecological validity of this research (Haigney & Westermen, 2001).

Horrey and Wickens (2006) conducted a meta-analysis using published data from 23 experimental studies of distraction effects of phone use. They found that phone use was associated with definite costs to driving performance, but that these costs were to measures of response time and not for measures of lane-keeping or tracking performance. On average, the decrement in response time associated with phone use while driving was 130 milliseconds. They found that hands-free phone use did not reduce these costs, which led them to the conclusion that the main effect of phone use was the cognitive distraction. They also found that conversations with passengers were just as detrimental to driving performance as cell phone conversations.

McCartt et al. (2006) reviewed over 20 studies that assessed the crash risk associated with cell phone use while driving. They noted that most states do not provide data elements on police report forms to record drivers' phone use. Moreover, as noted above, even when data elements are available, phone use data obtained from crash reports are unreliable. They concluded that for accurately assessing crash risk, it is essential that phone use among crash-involved drivers be established independently. Several studies have been conducted using cell phone company billing records for this purpose, however these have all been conducted in other countries because cell phone billing records have not been available in the United States. One such study was conducted in Toronto (Redelmeier & Tibshirani, 1997). Researchers obtained cell phone company billing records from approximately 700 Canadian drivers to establish phone use at the time of the crash. Crash-involved drivers were used as their own controls in a case-crossover design. Phone use at the time of the crash was compared with phone use among the same drivers at a comparable time of day during the week prior to the crash. They found that drivers' use of a cell phone up to 10 minutes before the crash was associated with a fourfold increased likelihood of being involved in a crash. Hands-free phones did not appear to help, however the study may not have had sufficient statistical power to assess this effect.

A similar study was undertaken in Perth, Western Australia (McEvoy et al., 2005), in which phone records were obtained for approximately 500 drivers involved in crashes that required hospital treatment. Using the same type of design, they found a fourfold increase in the risk of serious crash involvement among drivers using a phone at the time of the collision.

Despite their concerns about existing methods, McCartt et al., (2006) concluded that phone use represents a significant driving hazard. Moreover, because phone use may involve a relatively extended period of exposure relative to other shorter-duration distractions such as eating, drinking, or radio-tuning, it likely represents a bigger problem than these other common in-vehicle tasks.

4.1.1 Future Problems With Cell Phone Use

While phone use may represent a relatively small proportion of the current incidence of distracting activities, two trends combine to suggest that the associated problems may increase. First is the continually increasing number of cell phone users. Second is the fact that phones are now being used for many more activities than for talking. Specifically, they are being used for text messaging and to download audio or video from the Internet, to play games and in some countries to pay bills (Trezise et al., 2006). Moreover, it is younger people who are leading the way in these secondary uses of mobile phones (Trezise et al., 2006). To the extent that such auxiliary uses of cell phones are being performed largely by drivers without fully-developed driving skills, we may expect to observe a synergistic acceleration in the resulting safety problem. Hosking, Young, and Regan (2006) examined the effects of text messaging on the driving performance of young novice drivers in a driving simulator. Drivers were instructed to initiate text messaging to coincide with programmed scenario events. They found that retrieving and sending text messages had a detrimental effect on driving performance. Specifically, when text messaging, drivers were more likely to drive outside the lane boundaries and were less likely to respond appropriately to traffic signs. Driving while text messaging was also associated with a 400 percent increase in the amount of time spent looking away from the road, relative to driving without text messaging. In particular, drivers spent approximately 10 percent of the time looking away from the road when driving normally, versus 40 percent when text messaging. These authors reported the results of a separate Australian study in which it was found that 30 percent of drivers surveyed had sent text messages while driving. They concluded that mobile phone safety education and advertising campaigns should be targeted heavily to younger drivers.

4.2 In-Vehicle Route Guidance Systems

In-vehicle route-guidance or navigation systems are designed to guide drivers to a specified destination. Drivers enter a destination and the system provides a route from the vehicle's present location to the destination. While such systems may be helpful to drivers in unfamiliar locations, they have the potential to distract drivers in several ways. These include the physical distraction associated with manual destination entry, which typically uses a keyboard; the visual distraction when looking at the display while entering a destination or viewing a map or directions; the aural distraction when listening to auditory turn-by-turn instructions; and also the cognitive distraction when the driver thinks about the information presented by the system. There is also some evidence to suggest that the mere presence of a navigation system in a vehicle might encourage increasingly frequent and unnecessary use of the system, including browsing through lists of attractions (Burnett, Summerskill, & Porter, 2004).

Destination entry can be a time-consuming process and is considered the most distracting component of using in-vehicle navigation systems (Young et al., 2003). Tijerina et al., (1998) examined the effects of destination entry using four route guidance systems on closed-course driving performance. Three systems required manual entry while the fourth used voice commands. They found that destination entry using the visual/manual systems had a generally higher potential for distraction than the voice activated system. This was evidenced as longer completion times, more frequent glances at the device, longer eyes-off-road times, and a greater number of lane exceedances. They concluded that destination entry using voice recognition technology was less distracting than manual entry (Tijerina, Parmer, & Goodman, 1998).

Navigation systems have several ways of presenting route guidance information, including visual displays and audio messages. Visual displays can be either maps or turn-by-turn instructions. Because most information needed for driving is obtained visually, it has been assumed that audio messages would be less distracting than information presented on visual displays. Srinivasan and Jovanis (1997) used a driving simulator experiment to compare different methods of information presentation, which included a map display alone, map plus visual turn-by-turn displays, map plus voice guidance, and a paper map. The voice guidance system was associated with the best driving performance, defined as the fewest navigational errors, lowest workload, and fastest speeds. Because drivers were instructed to maintain posted speeds, slower speeds were interpreted as indicating greater distraction. Use of the paper map resulted in the slowest speeds, highest workload and most navigational errors. Based primarily on these results, voice instructions are considered to be less distracting than a visual display and turn-by-turn instructions are less distracting than maps (Young et al., 2003; Trezise et al., 2006).

4.3 In-Vehicle Internet and E-mail Capabilities

The availability of in-vehicle Internet and e-mail access is predicted to become an important component of new infotainment systems (Young et al., 2003). Drivers will be able to download traffic updates and weather reports, among other things, and to access e-mail and web capabilities more generally. As the functionality of in-vehicle computing capabilities approaches that of desktop or portable computers, secondary task possibilities will proliferate and it will become increasingly difficult not only to define secondary task boundaries but also to determine which tasks may be acceptable to perform while driving and which may not. Moreover, given drivers' freedom to determine when and how much attention to divert from driving to perform secondary tasks, it is likely that some drivers may choose to switch between multiple secondary tasks while driving, much as they do when using a personal computer. This scenario could create significant challenges for interface designers and for those who seek to develop methods for assessing the distraction potential of secondary tasks.

4.4 Radio Tuning/CD Players

Few studies have considered the distracting effects of operating vehicle radios or other entertainment systems (e.g., cassette, CD) because these secondary tasks are generally considered to pose acceptable levels of distraction. Several studies have demonstrated that tuning or even simply listening to a radio while driving can distract a driver and degrade driving performance (Young et al., 2003). Research has also suggested that operating a CD player while driving is more distracting than dialing a mobile phone or eating (Young et al., 2003).

5.0 COUNTERMEASURES FOR DISTRACTED DRIVING

5.1 Behavioral Strategies

Developing effective countermeasures for distracted driving is hampered by the abovementioned difficulties in defining, observing, and measuring driver distraction. This also holds true for measuring countermeasure effectiveness. The standard behavioral countermeasures of laws, enforcement, and sanctions, which have been used successfully for alcohol impairment, safety belt use, aggressive driving, and speeding, are considered unlikely to be effective for distracted driving (NHTSA, 2006). The main reason is that distracted driving is more than a driving or transportation system issue. Rather, it is a societal issue, resulting in part from lifestyle patterns and choices. This point is also made by Lee and Strayer (2004), who suggest that social norms govern what constitutes an acceptable risk. For example, if it is socially acceptable to use a cell phone while driving, then it may be very difficult to influence this behavior. The same is true for other more commonly accepted distractions such as eating or drinking, and listening to music.

According to NHTSA, the obvious way to reduce distracted driving is to convince or require drivers to pay attention to their driving. Behavioral strategies to reduce distracted driving include attempting to remove underlying causes and promoting awareness of the risks (NHTSA, 2006). Removing the underlying causes of distraction may be extremely difficult due to the lifestyle component mentioned above. However, one noted exception is that some graduated driver licensing (GDL) provisions may help reduce distraction among younger drivers. GDL is a three-phase system for new drivers that consists of a learner's permit, a provisional license, and a full license. GDL helps new drivers acquire experience gradually by limiting exposure to higher-risk situations such as nighttime driving. As of August 2004, 47 States and the District of Columbia had some GDL components. GDL components that may have an impact on driver distraction include limiting the number of passengers and prohibiting cell phone use by drivers with learner's permits, provisional licenses, or by drivers under 18. There have been no evaluations of the GDL distraction provisions; however there is evidence supporting the overall effectiveness of GDL in reducing crashes and injuries among teenage drivers (Baker, Chen, & Li, 2007; NHTSA, 2006).

5.1.1 Cell Phone and Related Laws

The use of hand-held phones by drivers is illegal in most European Union countries, in all Australian states, and in the Canadian province of Newfoundland and Labrador. Japanese drivers are not permitted to use any type of phone; however enforcement only occurs with another traffic violation. In the United States, use of hand-held phones is not permitted in Connecticut, New Jersey, New York, and the District of Columbia. California's ban on hand-held phones will begin in 2008. Several additional communities prohibit hand-held cell phone use while driving. Twelve States prohibit all cell phone use by drivers under 18 or

21 and several States prohibit use among drivers with GDLs and school bus drivers. Other States do not allow communities to restrict cell phone use. Legislatures in over two-thirds of the States have considered bills related to cell phone use in recent years. The National Conference of State Legislatures monitors developments in legislation pertaining to distracted driving and maintains a Driver Focus and Technology Database that summarizes the current status of existing or pending restrictions on wireless or cellular phones. This information is available at: www.ncsl.org/programs/transportation/DRFOCUS.htm

The effectiveness of New York State's cell phone law has been evaluated. Initially, there was significant compliance, but 18 months later phone use had increased to a level that was not significantly different from that observed before the law took effect. It was concluded that a drop-off in publicity and the lack of a publicized enforcement campaign may have combined to reduce compliance to this law (McCartt et al., 2006). Several economic analyses have been conducted to compare the costs and benefits associated with cell phone use restrictions. These studies do not provide a clear consensus on the net effects of these laws (McCartt et al., 2006).

Other than cell phone laws, there are no laws that address driver distraction explicitly. However, reckless driving laws implicitly prohibit driving while significantly distracted. No studies have evaluated whether such laws affect distracted driving, however it is expected that any such law will have little or no effect unless it is vigorously publicized and enforced (NHTSA, 2006).

5.1.2 Communications and Outreach on Distracted Driving

Developing effective communications and outreach programs for the general public is difficult due to the wide range of possible sources of distraction. Some distractions occur outside the vehicle and are thus not under the driver's control. Other distractions, such as listening to the radio, music, or eating, are intentional and may help keep drivers alert on a long trip (NHTSA, 2006). Some States (California, New York) have conducted driver alertness campaigns for the general public, but there are no known studies of the effects of these campaigns on driver knowledge, attitudes, or behavior (NHTSA, 2006).

To the extent that distraction is a problem for commercial drivers, employer programs may be a viable approach; however, to date employers have developed or implemented programs to combat employee drowsiness but not driver distraction (NHTSA, 2006).

The National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board undertook a study to identify countermeasures for reducing crashes of drowsy and distracted drivers (Stutts et al., 2005b). As part of this study, the authors described a data collection initiative in Virginia aimed at improving the reliability of reporting associated with distraction and other forms of driver inattention. In addition to the improvement in the quality of reporting, they argued that such activities also help increase awareness of distraction by law enforcement officials.

5.2 Environmental Strategies

The NCHRP report (Stutts et al., 2005b) identifies two broad objectives relating to the environment, including (1) making roadways safer for drowsy and distracted drivers, and (2) providing safe stopping and resting areas. Two specific strategies were judged by Stutts et al, (2005b) as having the highest potential effectiveness. These included installing shoulder and/or centerline rumble strips and improving access to stopping and resting areas. The main weakness of this report is that no distinction is made between approaches to address distraction-related problems and the broader problems of inattention and driver fatigue, which have different causes. Countermeasures that address inattention in realtime may be useful both for inattention generally and for distraction in particular, however countermeasures that address the underlying causes may not work equally well for all categories of inattention. For example, rumble strips may have the potential for improving the alertness of drivers who allow their vehicles to wander from the travel lane for whatever reason; however the placement of and access to rest areas are not likely to address distracted driving unless they include offering services such as wireless Internet access, which might encourage drivers to defer engagement in secondary tasks until they arrive at the rest area.

5.3 Vehicular Strategies

5.3.1 Guidelines for Interface Design

Vehicular strategies for mitigation of driver distraction are focused primarily on the design of interfaces associated with in-vehicle systems that have the potential for distraction. Considerable effort has been devoted by the automotive manufacturers, not only in North America but also in Europe and Japan, to the development of design guidelines to optimize the interface characteristics associated with in-vehicle technologies. Specifically, during the past decade, there have been three major HMI guidelines developed, including one each in Europe, the United States, and Japan (Eckstein & van Gijssel, 2006). In the United States, the Alliance of Automobile Manufacturers drafted a set of voluntary design, installation, and use guidelines for telematic systems. These guidelines were based on the European Statement of Principles on Human-Machine Interface and comprised a "best practices" document to address the safety aspects of driver interactions with future in-vehicle and communications systems (Eckstein & van Gijssel, 2006). Transport Canada has funded research to assess these guidelines. Results of this work have concluded that while the principles are generally valid, they are difficult to apply and the results difficult to interpret (Morton & Angel, 2005).

Burns (2007) assessed the effectiveness of the various guidelines more generally. He concluded that despite the existence of numerous standards and guidelines and despite the significant improvements in telematics interfaces in the past 10 years, designers are not consistently applying principles of good ergonomic design. Burns argues for a mechanism within the product development process that would allow the risks of driver distraction to be routinely and systematically considered during the product design, development, and testing (Burns, 2007). However, it is increasingly difficult to focus exclusively on the auto manufacturers because technologies with significant distraction potential may also be purchased as aftermarket devices or as devices brought by drivers into the vehicle.

Improvements to human machine interface design that improve usability may also have unintended effects. Lee and Strayer (2004) discussed the "usability paradox," which occurs when the improved design of an in-vehicle device makes it easier to use and thus less distracting. When drivers become aware of the increased ease of use, they may use the device more frequently, thus increasing their overall exposure to risk. The "usability paradox" is one form of behavioral adaptation or risk compensation, which has been proposed to explain why highway and vehicle safety improvements may have short-lived effects (Smiley, 2000; Wilde, 1982). Accordingly, such improvements as clearer roadway delineation, wider lanes, and even such safety features as air bags may eventually lead some drivers to feel safer and therefore drive faster, thus possibly reducing some of the safety benefits associated with the improvements.

5.3.2 Advanced Driver Assistance Technologies

A few new vehicles are being sold with in-vehicle technologies that can detect driver distraction by monitoring driver performance and eye-glance directions. They may also be able to warn drivers of risky situations and control their use of distracting devices, such as wireless phones. For example, some Volvo vehicles have a system called the Intelligent Driver Information System, which delays incoming phone calls or other nonessential information if the driving situation is busy (e.g., during acceleration). Toyota recently announced that its 2008 Lexus LS600hl will be equipped with a camera to monitor the driver's face. If the glance-monitoring system detects that the driver is not looking ahead when the radar detects a potential crash, the driver will receive a warning.

In anticipation of the emergence of multiple, distracting technologies, NHTSA has undertaken a research program with Delphi Electronics to determine the safety benefits associated with a system that employs in-vehicle analysis of drivers' glance directions to monitor and manage driver distraction. The system integrates driver data and traffic data collected from radar and other sensors to control the information flow to the driver. The goal is to develop and test a prototype adaptive interface that incorporates decision rules to prioritize information flow to the driver, to alert distracted drivers, and to improve the performance of collision warning systems. The program is called SAVE-IT (SAfety VEhicle using adaptive Interface Technology (www-nrd.nhtsa.dot.gov/departments/nrd-13/newDriverDistraction.html).

6.0 RESEARCH DIRECTIONS

1. Naturalistic studies providing incidence data on distracting activities have typically been small-scale studies. A larger, more representative, study of the incidence of distracting activities is planned as part of the SHRP II program. The design of this program should give a high priority to driver distraction to ensure that appropriate data are obtained to better understand trends in driver distraction.

2. Better reporting of driver attention status for crash-involved drivers is needed to provide better estimates of the incidence of distraction in crashes. Research is needed to identify ways to reduce the percentage of unknown attention status among crash-involved drivers.

3. In-vehicle and portable information and entertainment technologies are emerging rapidly, making it increasingly difficult to determine the scope of the potential distraction problem. An effort is needed to develop an inventory of existing and emerging technologies and services accessible to drivers. From this, research is needed to define a taxonomy of driver distractions and specific sources.

4. The extent of distraction among drivers is determined by drivers' willingness to engage in potentially distracting secondary tasks while driving. Analysis of naturalistic data is needed to understand the factors that contribute to drivers' willingness to engage in potentially distracting tasks while driving. Information is needed to determine the extent to which the presence of in-vehicle technologies encourages unnecessary or incidental use while driving.

5. An assessment of potentially distracting events and objects, such as dynamic advertisements, that occur outside the vehicle is needed to better understand this part of the distraction problem.

6. Work should continue on the development of objective, standardized measures of distraction. Emphasis should be given to improving the reliability and validity of eye-glance measures.

7. Methods must be determined to estimate the benefits as well as the costs of various distracting activities.

8. To help anticipate future distraction problems, an effort should be undertaken to identify segments of the driving population or other transportation system users who may have future potential for increased incidence of distraction. Possible examples include police officers, emergency responders, pedestrians using portable communication or entertainment devices, and young drivers.

9. Evaluation of the effectiveness of State distraction-related laws is needed.

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