White Papers for: *"Toward Zero Deaths: A National Strategy on Highway Safety*

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SAFER DRIVERS

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FOREWORD

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PREFACE

While many highway safety stakeholder organizations have their own strategic highway safety plans, there is not a singular strategy that unites all of these common efforts. FHWA began the dialogue towards creating a national strategic highway safety plan at a workshop in Savannah, Georgia, on September 2-3, 2009. The majority of participants expressed that there should be a highway safety vision to which the nation should aspire, even if at that point in the process it was not clear how or when it could be realized. The Savannah group concluded that the elimination of highway deaths is the appropriate goal, as even one death is unacceptable. With this input from over 70 workshop participants and further discussions with the Steering Committee following the workshop, the name of this effort became "Toward Zero Deaths: A National Strategy on Highway Safety." The National Strategy on Highway Safety is to be data-driven and incorporate education, enforcement, engineering, and emergency medical services. It can be used as a guide and framework by safety stakeholder organizations to enhance current national, state, and local safety planning and implementation efforts.

One of the initial efforts in the process for developing a National Strategy on Highway Safety is the preparation of white papers that highlight the key issue areas that may be addressed as part of the process for developing a National Strategy on Highway Safety. Vanasse Hangen Brustlin was awarded a task order under the Office of Safety contract (DTFH61-05-D-00024) to prepare nine white papers on the following topics:

1. Future View of Transportation: Implications for Safety
2. Safety Culture
3. Safer Drivers
4. Safer Vehicles
5. Safer Vulnerable Users
6. Safer Infrastructure
7. Emergency Medical Services
8. Data Systems and Analysis Tools
9. Lessons Learned from Other Countries

The authors were challenged to be thought provoking and offer strategies and initiatives that, if implemented, would move the country towards zero deaths.

Driver error is the most often contributing factor in all crashes, so it stands to reason that strategies to address this element of the causation chain, will realize significant reductions in fatalities. In this paper, driver behavior experts from Westat Inc—Dr. Neil Lerner, Jeremiah Singer, and Dr. James Jenness—address four major issues to resolve in order to realize 'safer drivers': increased restraint use, reduced speeding, driver distraction, and younger drivers.

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SAFER DRIVERS BACKGROUND AND OVERVIEW

DRIVER BEHAVIOR AS A CONTRIBUTOR TO CRASHES

Driver behavior is not the sole cause of every fatal crash, but it is a contributing factor in the large majority of crashes. The estimate of driver contribution to crashes varies somewhat from study to study, and depends on definitions, crash type, vehicle population, and other factors. But the general finding has not altered substantially from the picture painted in the seminal multi-disciplinary crash study, the "Tri-Level Study" (Treat et al., 1979), which concluded that driver behavior contributed to over 90% of the crashes. Even though some researchers prefer not to use the concept of "cause," the dominance of driver behavior factors is evident in the findings (e.g., Blower & Campbell, 2002). Crashes typically come about through driver error, risky decisions, lapses of attention, and driver limitations (impairment, inexperience, age-related reductions in abilities, etc.).

Experts in the study of driver behavior view the driver as one element of a system, comprised of the driver, vehicle, roadway, and task. Safe driving represents an appropriate integration of these components. Likewise, a crash is due to an undesired interaction among these components. In this sense, crashes are not driver failures but system failures. The implication is that even though the driver component may be a key contributor to a crash, countermeasures to eliminate that type of crash or its consequences might be made to any of the components of the system. For this reason, there is considerable overlap in the kinds of initiatives that might be suggested in a Safer Driver white paper and those related to Safer Vehicles, Safer Infrastructure, Vulnerable Road Users, and Safety Culture.

MAJOR ISSUES IN DRIVER BEHAVIOR

There are many ways to categorize driver behavior issues. The "big three" topics have traditionally been speeding, occupant protection system use, and impairment. These areas have long and continuous histories of extensive research, education, enforcement, and evaluation. They deservedly receive this attention since they contribute to so many fatalities. Speed both increases the probability of a crash and the injury consequences. About three of every ten crash fatalities come from speed-related crashes (Carter, Smith, Srinivasan, & Sundstrom, 2009). Properly used occupant restraint systems are very effective in injury reduction, and the failure to use these devices is prominent in fatal crashes. About half of all fatalities in crashes are unrestrained (NHTSA, 2009b). Impairment, particularly alcohol use, is also highly represented in fatal crashes. About one-third of all fatal crashes involve an alcohol-impaired driver (Carter et al., 2009).

Other major issues include driver groups that are overrepresented in fatal crashes. Most prominent among these are older drivers and young, novice drivers. Older drivers are over-represented both because reduced perceptual/cognitive abilities contribute to crash involvement and because they are more vulnerable to injury in the event of a crash. Older drivers are dealt with in the white paper on Vulnerable Road Users, rather than in this paper. Novice teen drivers have a higher per mile crash rate than other driver groups, with numerous factors probably contributing to this. Although young/novice driver safety has been a significant concern for a long time, the focus until fairly recently had been on driver training and education. More recently, there has been much more intensive research into the causes of poor teen driver performance. Graduated driver licensing (GDL) has had a tremendous impact (Goodwin, Foss,

Sohn, & Mayhew (2007), and other options, such as driver monitoring, have also been getting more attention (e.g., Lerner et al., 2009).

Driver distraction has become a very prominent issue in recent years (Governors Highway Safety Association, 2010). The intense interest in this topic is fueled by the dramatic increase in the use of cell phones, the increase in the range of communications devices and applications, and the emerging technologies that will be in vehicles or portable. There is also the perception that multitasking is an increasingly common activity, or even a "lifestyle," among the population, whether driving or not.

These, then, appear to be the dominant broad topics to consider in addressing "safer drivers" initiatives. There are certainly additional topics that merit consideration, but this is a reasonable base for focus and encompasses much of the problem of driver behavior.

NOTEWORTHY RECENT TRENDS IN BEHAVIORS AND STRATEGIES

A variety of recent and projected changes to the population, transportation system, and broader culture may impact safer driver issues. Many important projections are provided in the white paper on "Future View of Transportation." In this section, we wish to highlight a few selected trends that have implications for safer driver initiatives.

- *Technologies that may be applied to safer driver countermeasures*: A major trend in our ability to deal with driver behavior issues comes from the continual evolution of practical technology and communications. We now have abilities to monitor many behaviors that drivers engage in and the capability to respond through feedback or direct intervention. This includes both vehicle-based and infrastructure-based detection. The U.S. Department of Transportation's IntelliDrive program (U.S. Department of Transportation, 2010b), now underway, will further enhance capabilities for infrastructure-to-vehicle and vehicle-to-vehicle communications. New vehicles themselves have increasing "intelligence" and the ability to serve as platforms for safety functions. Real-time image processing of video is a maturing capability that may offer future opportunities. Unobtrusive sensing of alcohol levels, physiological and neurocognitive status, point of gaze, and other characteristics are maturing. Technology for automatically recognizing and enforcing traffic violations is now commonplace. Sophisticated driving simulators are increasingly practical for driver evaluation and training. It would be a mistake to believe that all driver behavior concerns could be addressed with technology. But clearly we have the opportunity to envision new strategies based on the increasing power and reduced costs of technology.
- *Cultural shifts in communications, technology, and multitasking*: We may have to shift our perception of the driving task and what drivers are actually doing. Cell phones are now present in most vehicles; many individuals are no longer reluctant to converse while driving and text messaging is increasingly common (Madden & Rainie, 2010). New technologies and applications are available on devices that consumers can bring in to vehicles. Vehicles themselves are increasingly equipped with systems that provide information and entertainment to the driver. In addition to the specific sources of distraction, there is a more general trend to multitasking as a lifestyle. Particularly in younger age groups, individuals have grown up multitasking and recognize it as a normal part of what they do (Foehr, 2006). They may be particularly resistant to attempts to alter

this pattern. This of course has implications for the particular issue of distracted driving. But it may broadly affect how we characterize the driving task and how we design for driver safety. For example, roadway signs and markings or vehicle displays may have to compete harder for attention. Assumptions about driver reaction time for design purposes may require adjustment. Essentially, various driver behavior impacts of a more "wired" society remain to be seen.

- *Understanding what goes on in the vehicle*: In the past decade, an important new research methodology has matured and become more widespread. Small and relatively inexpensive instrumentation packages make it feasible to install sophisticated data collection and video systems in drivers' personal vehicles, so that rich information on naturally occurring behavior can be collected over extended time. Termed "naturalistic driving" research, this method became more prominent when a major influential study, commonly known as "the 100 car study" (Dingus et al., 2006), demonstrated the practicality and power of this method. Since then, a variety of naturalistic driving studies have been done and the Congressionally-created Second Strategic Highway Safety Research Program ("SHRP 2") now is in the process of sponsoring the largest study of this kind (Transportation Research Board, 2010). The plan is to collect data from about 3,000 drivers in six areas around the country. It is hoped that extensive and detailed SHRP 2 naturalistic driving data will provide important insights that can be brought to bear on the safer driver issue.
- *Past successes redefine the target populations*: There has been steady improvement in seat belt usage rates over the years. NHTSA's annual National Occupant Protection Use Survey (NOPUS) observed national occupant belt use rates below 60% when the survey program began in 1994 but it was 84% in 2009 (NHTSA, 2009b). Usage rates are substantially higher for those States with primary seat belt laws (88%) and meets or exceeds 90% in 15 States, DC, and Puerto Rico. Therefore the remaining nonusers of seat belts tend to be the most recalcitrant and resistant to previous safety strategies. This means more effective innovations will be required to make significant new gains. Similarly, numerous programs to address drink driving have reduced the degree of impaired driving among casual drinkers, but this means major gains will need to affect the more resistant drivers. Similar issues could arise with further successes in speeding, distracted driving, or other driver misbehavior. If there is a "zero death" objective, we will need to have a willingness to adjust the aggressiveness of driver countermeasure strategies to the population that has been most difficult to reach in other ways.

SELECTION OF STRATEGIES AND INITIATIVES FOR SAFER DRIVERS

Some form of driver behavior or driver state contributes to the large majority of highway fatalities. Given the many aspects of driver behavior and their critical importance to highway safety, it is not surprising that there is a long history of diverse efforts to improve driver performance. Any one of the major categories of strategies listed in this paper would itself support a long list of countermeasure concepts and safety initiatives. Therefore we have had to be extremely selective in the focus on strategies and proposed initiatives treated in this white paper. We have tried to identify the major areas of recent activity but certainly are not comprehensive. We have also focused on passenger vehicle drivers, as opposed to the additional specialized concerns that characterize heavy trucks, buses, other commercial vehicles, and motorcycles. In choosing specific initiatives to put forth, we were constrained to select only a

few from the many possibilities under each topic area. We have tried to emphasize those potential high-payoff ideas that are relatively new, not widely implemented, innovative, or just emerging as practical due to advances in technology or practice.

We have grouped the suggested initiatives under four broad strategies:

- Increase restraint use
- Reduce speeding
- Reduce driver distraction
- Increase safety of young drivers

Before moving to these four initiatives, we wish to note that driver impairment is not included within these initiatives. This in no way is meant to dismiss its importance. Impairment, and particularly alcohol impairment, is a prominent factor in fatal crashes. Close to one-third of all fatal crashes involve an intoxicated driver, with something on the order of 12,000 fatalities in crashes where at least one driver had a BAC of 0.08 or higher. There has been a great deal of effort devoted to reducing this toll, through efforts in deterrence, prevention, intervention, communications and outreach, the treatment of alcohol dependencies, and other traffic safety measures. We have found the review of these strategies and their effectiveness in the NHTSA document *Countermeasures that work: A highway countermeasure guide for State highway safety offices* (NHTSA, 2010), to be quite thorough and in line with our perceptions. The primary area where we would suggest significant new initiatives not fully covered there is in the area of vehicle-based alcohol sensing. In particular, the idea that alcohol sensing and interlock (or some other form of deterrence) technology can be provided as original equipment in passenger vehicles is very appealing. Currently interlock systems are used as a sanction or probation requirement for DUI offenders. While important, this is a limited strategy because: (1) most alcohol users are not detected or are able to avoid prosecution; (2) the benefit of the system is not usually maintained after the interlock is removed; (3) the fact that other family members may use the same vehicle imposes complications and burdens. A built-in alcohol detection capability in new vehicles overcomes all of these issues. The Driver Alcohol Detection System for Safety (DADSS) represents a large-scale government-industry cooperative effort to develop this concept. Since this initiative involves a vehicle subsystem, it is treated in another white paper on Safer Vehicles, and therefore is not discussed further here.

Given this, for this Safer Drivers white paper we have chosen to focus on initiatives in the areas of restraint use, speeding, driver distraction, and young drivers. For each of these topic areas, we provide a brief overview of safety activities in the area, and then propose several initiatives that have potential to substantially impact the reduction of driver-related crashes and fatalities.

INCREASE RESTRAINT USE

RECENT TRENDS IN UNRESTRAINED FATALITIES

Fatalities related to unrestrained vehicle occupants have declined in recent years, moving from 16,430 fatalities in 2004 to 12,860 fatalities in 2008 (Figure 1). Moreover, this decrease cannot be entirely attributed to the significant drop in all fatalities in 2008, since unrestrained occupant fatalities have been declining steadily since 2004. This steady decline may be due to a concentrated nationwide effort to increase restraint use and a rising awareness in the driving public about proper restraint use. A 2009 survey of State highway safety plans (SHSPs) observed that the majority (47 of 51) of SHSPs contained strategies related to occupant restraint.

Another aspect shown in Figure 1 is the percentage of all fatalities that were related to unrestrained occupants. In 2007 and 2008, there was a much larger percentage than in previous years. This indicates that although the absolute number of unrestrained occupant fatalities was decreasing, larger strides were made in other areas (e.g., young drivers, work zones, etc.).

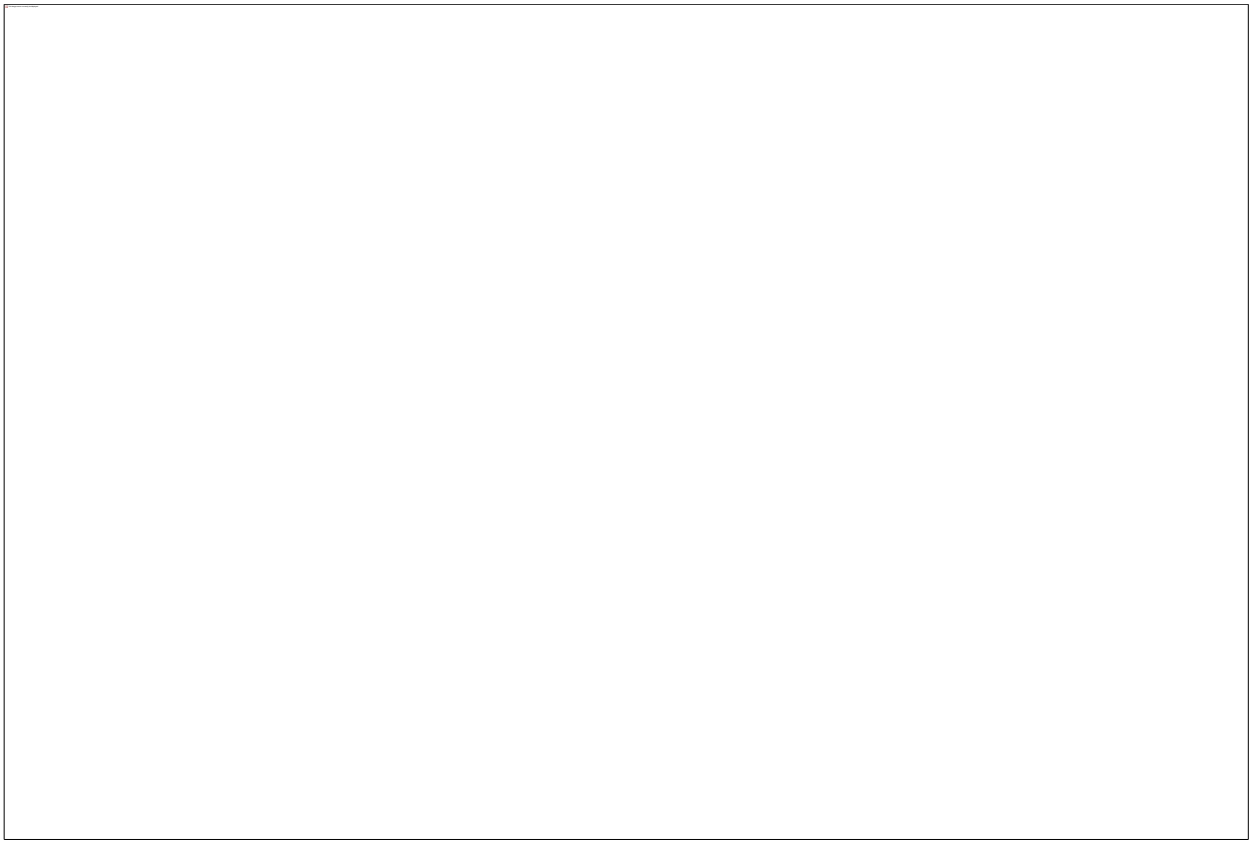

Figure 1. Trends in unrestrained occupant fatalities.

Figure 2 shows the trend of unrestrained occupant fatalities compared to percentage of seat belt use. Seat belt use across the nation has been rising since 2006, reaching a peak average of 83% in 2008. Additionally, the number of States with seat belt use rates 90% or higher has doubled since 2004, and the number of States with seat belt use rates less than 75% has decreased from 14 to 8.

Figure 2. Unrestrained occupant fatalities compared to seat belt use.

The shift in population attitudes and behaviors regarding seat belt use has been a major success story. Over a single generation, we went from a nation of rare seat belt users to one of predominant seat belt use. In the mid-1980s, only about a third of people wore seat belts while today the number approaches 9 out of 10. Yet failure to use occupant restraint systems still remains a major highway safety concern. Seat belt use is notably lower among a number of high risk driving groups (e.g., rural drivers, teens, demographic populations) and driving conditions (e.g., night, surface streets) (NHTSA, 2009b). And most significantly, the failure to use restraints characterizes the victims of fatal crashes; more than half of all passenger vehicle fatalities were unrestrained, and this is particularly the case for night crashes (NHTSA, 2009c).

Because occupant restraint systems are such an effective fatality reduction countermeasure, even small increments in the percentage of restraint system users can have significant benefits in terms of reducing deaths. Therefore, despite the steady year to year increases we have witnessed over a number of years, improved compliance with seat belt laws and other occupant restraint provisions remains a significant target for safer driver countermeasures. Of course, occupant protection systems themselves are critical and are addressed in the Safer Vehicles white paper. This document is more directly concerned with *driver behavior* regarding occupant restraint systems.

INCREASE RESTRAINT USE STRATEGIES

Ongoing efforts in the restraint use area typically fall under several major categories: seat belt use laws, with particular emphasis on primary enforcement laws; law enforcement, with

emphasis on high visibility campaigns; technology enhancements, particularly enhanced seat belt reminder systems; child restraint, in terms of laws, education, and products; and communications and outreach, which is frequently done in conjunction with these other strategies. This section gives a brief overview of each of these. Following that, a set of promising initiatives is offered. The suggested initiatives focus on less-explored or developed approaches toward reducing deaths due to driver behavior related to restraint system use.

Seat Belt Use Laws, Primary Enforcement Laws

All States but one have laws that require adult seat belt use in front seats. However, these laws differ in a variety of aspects (Governors Highway Safety Association, June 2010b), including who is covered (by age), the seat positions that require wearing a seat belt (front seat only or all seats), and the nature of fines for offenses (first offense maximum fines range from $10 to $200). One of the most significant differences among State laws is whether the law is primary or secondary. Primary seat belt laws allow enforcement personnel to issue a ticket even if no other traffic offense has taken place. Secondary laws only allow a ticket to be issued when there is also another citable traffic infraction. Only 31 States and the District of Columbia have primary seat belt laws; 18 States have secondary laws (IIHS, June 2010b). Seat belt usage is substantially higher in States with primary laws (88% versus 75% in 2008). Despite the magnitude of this difference, there remains opposition to upgrading secondary laws, based on perceptions about individual rights and the possibility of inappropriate enforcement (e.g., profiling). There has been a trend to upgrading seat belt laws to primary status, but many States are still characterized by secondary laws, low fines, and limited seat positions.

Restraint System Law Enforcement, High Visibility Enforcement

Enforcement is a critical element in achieving better rates of restraint system use. A widely adopted model is to employ high visibility short term enforcement in an intense campaign that couples ticketing efforts with media coverage, public information and education, and social marketing activities. The Click It or Ticket program is the prototype campaign, which began with a North Carolina program in 1993 and rapidly became adopted by more jurisdictions through the 2000's (Tison & Williams, 2010). These programs have been successful in promoting seat belt use, increasing awareness of seat belt laws, and modifying public perception of the likelihood of enforcement (Lucke et al., 2004; Tison & Williams, 2010). Other enforcement efforts have included programs of sustained enforcement and night enforcement (NHTSA, 2010), but these have not been as prominent as the Click It or Ticket type of efforts.

Technology, Enhanced Seat Belt Reminders

Some efforts to improve driver behavior with respect to seat belt use have been technological. The primary example is the installation of enhanced seat belt reminder systems as standard equipment in some vehicles. These systems provide visual or auditory alerts that go beyond the rather minimal U.S. requirements for reminding the driver. These systems are associated with increased rates of seat belt use and they are becoming more common among new vehicles (Freedman, Lerner, Zador, Singer, & Levi, 2009).

Other applications of technology are also being explored. Interlocks of various sorts alter some aspect of the vehicle if a seatbelt is not used. Ignition interlocks, which prevent the vehicle from being started, are prohibited by law. However, there is research or recommendations regarding systems that delay the ability to shift the vehicle from Park into gear and with lockouts of the

vehicle infotainment system (e.g., Van Houten, Malenfant, Reagan, Sifrit, & Compton, 2009; Eby, Molnar, Kostyniuk, & Shope, 2004). Monitoring systems that report failures to use seat belts to some authority have been included in fleet monitoring systems and experimental programs on teen driving (see Lerner et al., 2009).

Child and Infant Restraint Systems

All 50 States and the District of Columbia have requirements for child safety seats, although the provisions regarding child age, height, or weight vary (Governors Highway Safety Association, July 2010). Almost all States (47) and the District of Columbia also have booster seat laws for children too large for child safety seats. The issues and strategies associated with children are different from those of adults. For adults, the issue is motivating them to use a simple device (seat belt) that is already present in the vehicle. For child restraint, there are issues of understanding what is required, acquiring safety seats, knowing how to properly install and use them, and motivating consistent use. The extent of child restraint use is quite high, especially for infants and toddlers, exceeding 90% (Luke et al., 2004; NHTSA, 2009d). Usage is somewhat lower among some demographic groups, which may be due in part to the costs of the seats. However, the high use rates do not mean that the child restraints were being used properly and that the child was afforded the full degree of protection. In fact, improper use remains quite high, a finding that has been replicated in a number of studies since the 1980's (NHTSA, 2010). Consumers have difficulty understanding how to properly install and use the seats. Related to this, there are also compatibility problems; not all seats fit all vehicles. Various strategies have been used to try to address this problem, such as hands-on training, child passenger inspection stations, and efforts to standardize installation methods.

PROMISING INITIATIVES

There are well-established benefits to familiar strategies, such as primary enforcement laws, high-visibility enforcement, increased penalties, and (under appropriate conditions) communications and outreach (Lucke et al., 2004). These certainly merit continued application and more widespread use. In this section we put forth five initiatives for less familiar and more innovative approaches that will promote further progress toward the Zero Deaths goal. The suggested initiatives are:

- Implement effective nighttime enforcement
- Install seat belt reminder systems and other vehicle interventions
- Detect and alert for unbelted rear seat passengers
- Devise teen-oriented vehicle systems
- Improve system design for child safety seats

Implement Effective Nighttime Enforcement

Seat belt use is somewhat lower at night, which may be due to lower probability of enforcement, driver demographics, alcohol use, or other factors. Furthermore, a higher proportion of nighttime crash victims are found to be unbelted. NHTSA (2010) indicates that almost two-thirds of nighttime fatalities did not use restraints, whereas this number was just under half during the day. Since crash involvement rates are much higher at night than during the day, and night drivers and crash victims are less likely to be restrained, nighttime enforcement of seat belt laws is obviously important. Furthermore, evidence suggests that effective night enforcement programs also

improve the rate of seat belt use during the day. However, despite its importance, night enforcement is also difficult and enforcement campaigns typically focus on daytime conditions.

Night enforcement programs have been promoted in recent documents on seat belt countermeasures (e.g., Bolton, 2008; NHTSA, 2010; Tison & Williams, 2010) and there have been a number of demonstration projects using a variety of methods. NHTSA's document on "Nighttime Seat Belt Enforcement Strategies" (http://www.nhtsa.gov/DOT/NHTSA/Click%20it%20or%20Ticket/Articles/Associated%20Files/CIOT09_WTSC_NightSeatBelt.pdf; accessed June 27, 2010) provides capsule descriptions of a number of these. It is evident that the success of high visibility daytime Click It or Ticket programs can be adapted to night driving conditions with some success. More needs to be done to identify the optimal methods and quantitative benefits.

Visibility into the vehicle is obviously a critical concern at night. Programs have tended to use roadway locations with good in-place lighting (e.g., intersections and ramps), but some have deployed portable light towers or set up checkpoints. Technology can be an important aid to night enforcement of seat belt laws. Night vision goggles and infrared spotlighting have been successfully used to identify violators. However, NHTSA's Click It or Ticket program document "Nighttime Seat Belt Enforcement Strategies," warns "Due to the adverse public reaction to the use of these devices seen in one of these programs [that used night vision goggles], use of nighttime vision devices such as goggles or scopes is not recommended." Experience has been more positive in other jurisdictions. It should be noted that in the "problem" State, the governor actively opposed the program and derided it as government intrusion and "big brother" tactics. This political and public perception is obviously an enforcement concern, as it is with other enforcement strategies. Rather than dismiss the use of technology, we would suggest that first, any such program should have political buy-in before implementation, and second, that attention be given to the appearance of the enforcement activity. The almost military appearance of high-tech roadside teams might look intrusive and threatening to the public. Even though we would like the enforcement campaign to be highly visible, the night vision technology itself can be less evident. We suggest this initiative develop more public-friendly ways to implement night vision technology so that enforcement remains effective while public and political resistance is reduced.

Related to this technology issue, there is also the prospect of automated detection and even automated enforcement of seat belt use. Photo-imaging techniques can be used to analyze whether a driver has a shoulder belt on and this can be implemented with night vision capabilities. At least one manufacturer is promoting such a product (http://www.seatbeltcamera.com/) but we have not seen more general reports of research or evaluation on this type of device.

In summary, this initiative seeks to promote greater use and public visibility of night enforcement of seat belt laws. Night enforcement techniques should be refined and evaluated for determining the most effective methods. Greater use should be made of night vision technology, but advances must include design and implementation in a manner that is not disturbing to the public.

Enhanced Seat Belt Reminder Systems and Other Vehicle Interventions

The driver's motivation to wear a seat belt may be greatly influenced by the type of feedback the vehicle provides to the driver. The U.S. minimum requirements for seat belt warnings are limited in effectiveness. FMVSS 208 requires only a 4- to 8-second audible signal upon vehicle ignition

and a visual icon persisting for 60 seconds. This is not effective as a reminder, and certainly not as a motivator for those most reluctant to use their seat belts (Transportation Research Board, 2003). Many vehicle manufacturers now voluntarily install enhanced reminder systems as standard equipment. These enhancements include more conspicuous visual or auditory signals, displays for vehicle occupants other than the driver, more persistent warnings, and feedback that changes in urgency as a function of time, speed, or other factors. Recent research (e.g., Freedman, Lerner, Zador, Singer, & Levi, 2009) has demonstrated that enhanced seat belt reminder systems significantly increase seat belt use rates (typically in the range of 3-4 percentage points, from a baseline [no enhanced system] of about 85%) and has pointed to some of the characteristics of more effective systems. Consumer acceptance of these systems is generally good. Broader deployment of more effective systems must be encouraged, and ideally mandated through voluntary standards or regulation.

In addition to enhanced reminders, the vehicle can respond to the detection of an unbelted driver in other ways. Some NHTSA research has pointed to the potential of a built-in delay in the ability to shift into gear if the driver is not wearing a seat belt (Van Houten, Malenfant, Reagan, Sifrit, & Compton, 2009). Some have suggested the vehicle infotainment features be locked out (e.g., Eby, Molnar, Kostyniuk, & Shope, 2004). While these may be more intrusive measures than reminder systems, they do not preclude operation of the vehicle (as ignition interlocks do) and more aggressive countermeasures may be required for those most resistant to other strategies. If these possibilities are seen as too stringent for the general driving population, they may merit consideration for certain violator groups, such as those with multiple convictions of seat belt laws or other unsafe driving behavior.

Vehicle systems might also provide positive incentives for seat belt use. Some cars with active warning systems use seat belt pretensioners as part of the Forward Collision Warning System. In an imminent crash situation, the tightening seat belt provides a warning to the driver as well as injury prevention benefits. Drivers with such systems may perceive a benefit to wearing their seat belts in order to take advantage of this high-tech warning feature.

Detect and Alert for Unbelted Rear Seat Passengers

Seat belt warning systems are typically restricted to front seat passengers. In addition to cost considerations, this is due to concerns about inappropriate warnings that are triggered by cargo, pets, or other non-passenger situations. However, there are also good reasons for including rear passengers in seat belt warning systems (and in seat belt laws, which do not always include rear seat passengers). Seat belts provide important occupant protection benefits to rear passengers as well, and seat belt usage is lower for rear seat occupants than for front seat occupants (NHTSA, 2008a). Beyond this, however, there is a social facilitation benefit to alerting the driver or passenger to an unbelted occupant. Research has found that driver and passenger belt use are not independent. Nuyts & Vesentini (2005) observed that “drivers and passengers often behaved the same. They both wore or did not wear a seat belt.” Another observational study (Nambisan & Vasudevan, 2007) found that under various conditions (age/gender mix, rural or urban), passenger belt use was over 90% when the driver was belted and under 35% when the driver was unbelted. Motivating any one occupant to buckle up is likely to increase the likelihood of others to wear their seat belts. Furthermore, visual or audible alerts that are detectable by other vehicle occupants provide an opportunity for justifying requests to use the seat belt. People are generally reluctant to speak up in the social context of the car (Ulleberg & Must, 2005) and the suggested system would allow front and rear seat occupants to positively influence each other.

This initiative seeks to promote rear occupant seat belt use both by including these passengers in primary laws and by devising effective technology for detecting rear passenger presence. Occupant detection is typically based on sensing a weight on the seat pan. However, other technologies, such as thermal sensing or video image processing, are becoming more cost effective and could be used as well. These would make the system far more resistant to false warnings. Research and development work will be required to design and demonstrate a practical, low cost rear passenger detection system. Its use should then be promoted through vehicle rating programs (such as NCAP), safety promotional efforts, and voluntary design standards.

Devise Teen-Oriented Vehicle Systems

Teen drivers are a particular concern for seat belt compliance. The crash rate for teen drivers is exceptionally high and teen seat belt use is lower than for the general driving public. Therefore it is not surprising that the number of unstrained victims in the young (16-20) age group is exceptionally high (over 2,000 per year). About 55% of teen fatalities were unrestrained. Therefore teen drivers and their age-peer passengers are an important target for countermeasures.

An important element in dealing with this problem is to include clear restraint use requirements and effective penalties in graduated driver licensing (GDL) programs. Many States have seat belt use as a component of their GDL law. Beyond this, we see important opportunities to take advantage of new technology that can help motivate compliance and that is the focus of this proposed initiative.

“Smart keys” and other driver recognition technologies now make it feasible to determine who is driving a vehicle and adapt aspects of the vehicle system to that driver. The current Ford MyKey system provides a good example. When a “teen key” is used, various measures are put into effect, such as a cap on maximum speed, a limit on audio system volume, and earlier “low fuel” warnings. Included with these are changes related to seat belt non-use: there is a more persistent belt reminder chime and the audio system is muted. This current product demonstrates that it is commercially feasible to have restraint system features adapted to teen drivers when the system can recognize the driver or if the vehicle is designated as a teen vehicle.

NHTSA has already conducted research to derive a set of seat belt reminder system characteristics that would be optimal for teen drivers (Lerner et al., 2009). The factors that motivate teens to use or not use seat belts may be somewhat different than those that motivate adults. Furthermore, the tradeoff of effectiveness in promoting seat belt use versus consumer acceptance and preference factors may be different for teens than for adults. Suggested guidance also gives more consideration to the social aspects of seat belt use when there are multiple teens in the vehicle. The recommendations of this and other research should be exploited so that subsequent “smart key” systems provide the most effective belt reminder feedback systems to teen drivers and passengers. Beyond basic feedback systems, seat belt use should be included as an element in teen driver monitoring and reporting systems (see the Young Drivers section of this paper).

Improve System Design for Child Safety Seats

The proper installation and use of child safety seats is difficult for many consumers. The child safety seat system must be better devised for usability. We intentionally use the term “system,” rather than “product,” to emphasize that this initiative should look at the full spectrum of system

components that relate to proper use. This includes instructions and training; child safety seat and vehicle owner's manuals; product labeling; both vehicle and child seat design components and their compatibility; consistency in terminology, symbology, and color coding; and user feedback when improper use occurs. This systems approach is typical of good user-centered design but has been lacking in this area. There have been some initial efforts at this by the stakeholder community. One such effort has been the formation of the Joint Industry Working Group on LATCH. The LATCH Working Group is composed of members of the Juvenile Products Manufacturers Association, Alliance of Automobile Manufactures, and the Association of International Automobile Manufactures. To date they have created and published voluntary recommendations for vehicle labeling of LATCH anchors and attachments, use of LATCH and lap-shoulder belts simultaneously, and use of non-designated LATCH positions (LATCH working group makes progress, 2009).

It is not clear, however, that the full range of system components is being adequately addressed by the field. For example, child safety seat product owner's manuals are lengthy, complex, and quite different from one another. They often do not conform to good human factors practice for instructions (e.g., Singer, Balliro, & Lerner, 2003). Sections on child safety seats in vehicle owner's manuals may not be consistent in format and terminology with child safety seat manuals and instructions. Instructional videos or web sites are not exploited as tools. Products could be better designed in such a way that there is better feedback when something is done incorrectly. Some issues can be directly addressed by the manufacturers of child safety seats and others will require coordinated efforts among child safety seat manufacturers, the automotive industry, and other stakeholders.

IMPACT, COSTS, FUNDING

The table below summarizes the suggested initiatives to increase restraint use.

Table 1. Initiatives to increase restraint use.

STRATEGY	AIMED AT	POTENTIAL FATALITY REDUCTION	WHO BEARS COST	COSTS (IMPLEMENT/ MAINTAIN)	OBSTACLES TO IMPLEMENTATION
Implement Effective Nighttime Enforcement	All unbelted occupants at night	8,000 such fatalities; 10% reduction would save 800 lives	Violators, through fines; uncovered costs from enforcement	Night patrols; equipment for night observations; development costs for improved detection	Public and political acceptance of enforcement procedures
Install Seat Belt Reminder Systems and Other Vehicle Interventions	Unbelted occupants	5% reduction of 12,000 unbelted fatalities would save 600 lives	Automotive industry; ultimately consumer	R&D and production costs; consumers presumably incur any increased cost in vehicle production	Consumer complaint from those most resistant to wearing seat belts
Detect and Alert for Unbelted Rear Seat Passengers	Unbelted rear seat occupants, but also influences front seat occupants	1,200 passenger car and light truck unbelted second seat fatalities; 25% reduction would save 300 lives	Automotive industry; ultimately consumer	R&D and production costs; consumers presumably incur any increased cost in vehicle production	Consumer resistance if not highly reliable, resistant to false alarms
Device Teen-Oriented Vehicle Systems	Unbelted teen occupants in vehicles driven by teens	2,000 unrestrained teen fatalities; 20% reduction would save 400 lives	Automotive industry; ultimately consumer	R&D and production costs; consumers presumably incur any increased cost in vehicle production	Low consumer demand or resistance
Improve System Design for Child Safety Seats	Child occupants of passenger vehicles	550 fatalities < 10 years old, 35% not restrained. Assuming 20% effectiveness, saves about 100 children per year	Manufacturers of vehicles and safety seats.	R&D costs and production costs; ultimately may not be any additional cost to consumer	Need for agreement among numerous manufacturers of child seats, vehicles

REDUCE SPEEDING-RELATED FATALITIES

RECENT TRENDS IN SPEEDING-RELATED FATALITIES

Speeding related crashes are defined by NHTSA as crashes where a driver was charged with a speeding related offense or where the officer noted a speeding related contributing factor (racing, driving too fast for conditions, or exceeding the posted speed limit). As shown in Figure 3, speeding related fatalities remained at a relatively constant level from 2004 to 2007 and then decreased in 2008. As with other areas, this decrease in 2008 can be attributed to the nationwide drop in all crashes that was experienced in 2008. Examining speeding related fatalities as a percentage of all fatalities shows that relatively little changed in the nationwide picture. Although speeding related fatalities dropped from 13,040 in 2007 to 11,670 in 2008, the percentage of all fatalities remained almost the same, hovering around 31%. This indicates that there was little progress made in speed related safety when compared to other areas, such as young drivers or unrestrained drivers.

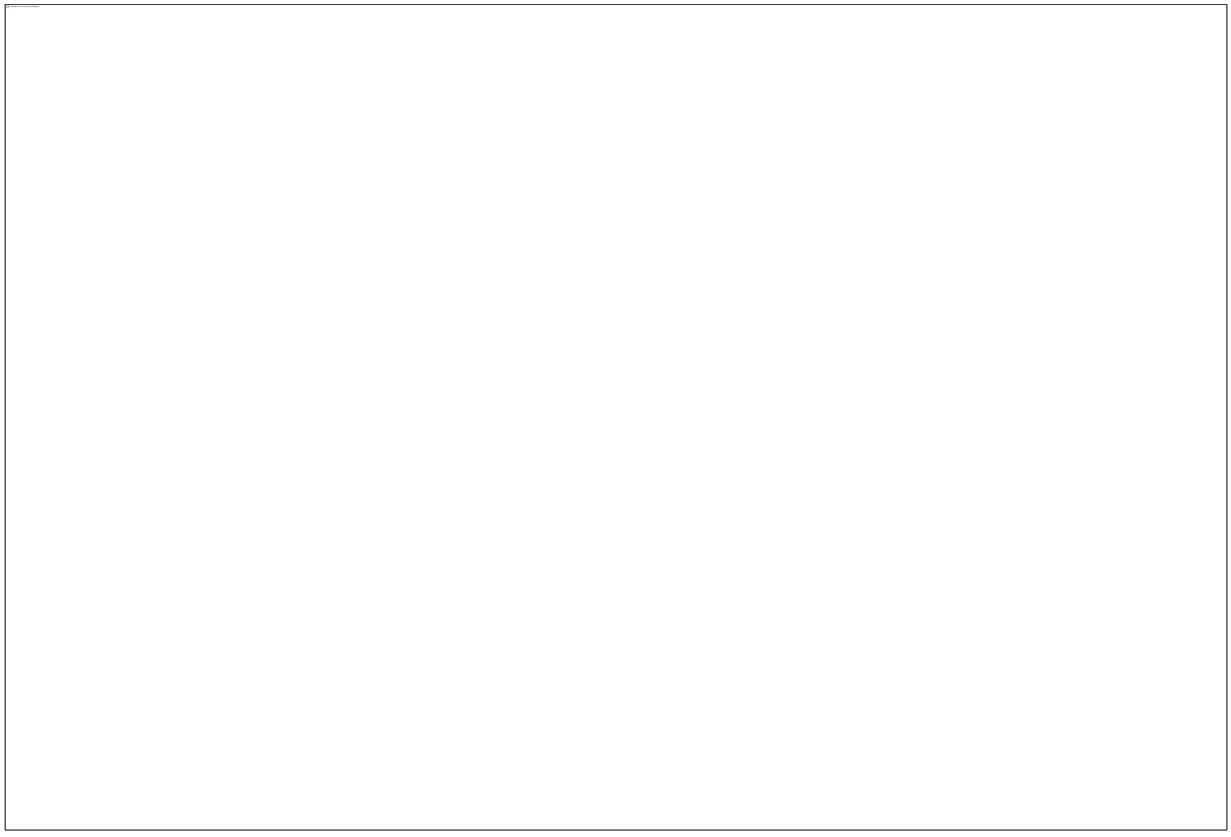

Figure 3. Trend of speeding related fatalities.

Speeding-related fatalities do not happen randomly; there are particular behaviors and conditions that are especially problematic. For instance, in 2007, young male drivers (ages 15 to 20) involved in fatal collisions were twice as likely to be speeding as male driver ages 35 to 44. Young drivers involved in speeding-related fatalities were also more than three times as likely to be unrestrained as their peers who were involved in crashes not related to speeding (NHTSA, 2008d). The combination of inexperience, poor judgment, and enjoyment of speed can be deadly for young drivers. Road type also plays a role in speeding-related crashes. Despite high travel

speeds, interstate freeways only account for 13 percent of speeding-related fatalities. The majority of speeding-related fatalities occur on two-way undivided roads, with low or high speed limits, and often in rural areas (Neuman et al., 2009). Adverse weather conditions do not have a substantial effect on speeding-related fatalities, but time of day does, with the rate of speeding-related fatalities climbing through the evening hours and peaking between midnight and 3:00 a.m. (NHTSA, 2008d). The high late night fatality rate is likely due in large part to an increase in the number of drivers impaired by alcohol. In fact, alcohol impairment is a major contributor to speeding-related fatalities: in 2007, 40 percent of drivers involved in fatal speeding-related crashes had blood alcohol concentrations of at least .08 (NHTSA, 2008d).

Despite the prevalence of speeding-related crashes and fatalities, speeding remains a common and often socially accepted behavior. A national survey conducted in 2002 asked drivers about their speeding behavior on four types of roads and found that between 73 percent and 83 percent reported driving faster than the speed limit on these roads within the past month (Royal, 2003). Half of respondents also reported driving ten miles per hour faster than the speed limit on freeways within the past month. Younger drivers and males were particularly likely to report speeding behaviors and enjoyment of speed. The survey also found that while most participants felt that current speed limits were "about right," a sizeable majority felt that police should not enforce speeding less than 10 miles per hour faster than the speed limit on most road types.

STRATEGIES TO REDUCE SPEEDING-RELATED FATALITIES

Like other major highway safety issues, the speeding safety problem should be treated with a multidisciplinary approach that includes roadway design and treatments, vehicle design, and efforts to influence driver attitudes and behavior. While other white papers in this series address the roadway and vehicle, this white paper focuses on the drivers themselves.

Behavioral countermeasures for speeding generally fall in three categories:

- Inform and educate about the dangers of speeding
- Enforce speed limits to punish and deter speeders
- Influence driver perception of speed and appropriate speed

Information campaigns in the absence of other countermeasures have limited success in reducing speeding and other unsafe behaviors (Rodriguez, 2002). Although drivers generally acknowledge that speeding is dangerous, speeding remains prevalent, in large part because the perceived risk of a speeding-related crash is low relative to the perceived benefits of driving fast (e.g., saving time, enjoyment of speed).

Enforcement of speed limits has become a key strategy to deter drivers from speeding. Conventional speeding enforcement methods, in which police officers detect speeders and write citations, are used extensively and have demonstrated success in speeding deterrence. Conventional speeding enforcement is most likely to be successful when: a) it targets the locations and conditions where speeding is most prevalent, b) the public is aware of enforcement through media communications and through the visibility of the enforcement itself, and c) the enforcement effort is sustained for more than one year (Transportation Research Board, 1998). Penalties for speeding violations must also be sufficiently punitive to be an effective deterrent. High visibility enforcement, in which a high intensity and highly publicized enforcement campaign is enacted for a relatively short period of time, can have a rapid and substantial effect on speeding, though these effects are likely to deteriorate over time if the enforcement is not

sustained (NHTSA, 2008c). Though conventional enforcement does help to reduce speeding, limited staff availability and budgets often prevent police departments from achieving an optimal level of deterrence.

Since the 1990s, some jurisdictions have supplemented their conventional enforcement efforts with automated speed enforcement (ASE). ASE systems use speed measurement devices and cameras to photograph speeding violations when they occur. A violation notice that includes photographic evidence of the violation is then delivered to the vehicle's owner. ASE units may be fixed at a single location or portable between locations. When implemented properly, ASE can act as a "force multiplier," substantially increasing the deterrent effect of enforcement without requiring a large dedication of police staff or budget. Despite the potential benefits, ASE is used in fewer than 60 jurisdictions in 12 States and the District of Columbia (IIHS, July 2010). ASE implementations have sometimes faced vocal public and political opposition, and legal challenges. Opponents of ASE often raise Constitutional issues such as the right to privacy and right to due process, though such challenges have not been successful in courts. Legal challenges have sometimes been successful on procedural grounds, however, when ASE operations have been found to be inconsistent with relevant laws. To be successful, an ASE program must a) be designed to maximize deterrence of speeding, b) gain the support and cooperation of stakeholders, c) engage the public with a proactive communication campaign, and d) carefully adhere to all of its legal requirements (NHTSA, 2008b).

The third category of behavioral countermeasure, influencing driver perception of speed, includes a variety of countermeasures such as road markings, roadway and roadside features, and speed feedback signs that can encourage drivers to choose safer speeds. Because these countermeasures are installed as part of the roadway infrastructure, however, they are not discussed in this white paper.

PROMISING INITIATIVES

The continued prevalence of speeding-related fatalities suggests that new and improved countermeasures are needed to make gains in this area. Two major initiatives are identified here as promising approaches for substantially reducing speeding-related crashes. Each initiative may involve multiple activities and approaches. The suggested initiatives are:

- Expand the use of in-vehicle speed feedback technologies.
- Use automated speed enforcement technologies to achieve broad area enforcement.

Expand the Use of In-Vehicle Speed Monitoring Technologies

Background

Recent advances in technology have enabled the development of in-vehicle devices that measure aspects of vehicle and driver performance, including speed, and provide feedback based on these measurements. Currently available devices typically measure performance using information from some combination of these sources:

- GPS, which determines the vehicle's current location, and can be used to calculate vehicle speed.
- The vehicle's on-board diagnostics port (OBD-II), which outputs data related to vehicle performance and component functionality.

- Device-based accelerometers, which measure longitudinal and lateral forces that provide an indication of the rate of acceleration and deceleration, turning and cornering speed, and vertical bumps (e.g., speed hump or pothole).

Though monitoring devices have not yet found widespread use, early experience among fleet vehicles and novice drivers suggests that they can achieve substantial safety benefits. In Arkansas, an ambulance fleet was instrumented with monitoring devices that gave feedback to drivers when they were speeding, cornering too fast, and performing other unsafe acts. The devices resulted in significant reductions in speeding and other violations, as well as a 20 percent reduction in vehicle maintenance costs (Levick & Swanson, 2005). In Israel, a corporate fleet of cars for employee use were instrumented with devices that monitored speeding, swerving, and hard braking. Drivers received instant feedback in the vehicle when an unsafe event occurred, as well as a monthly report that summarized their performance. Use of the devices led to a 38 percent reduction in crashes per 1,000 miles driven (Musicant, Lotan, & Toledo, 2007).

Though there has been relatively little experience with monitoring devices for novice teen drivers, early experience is promising. Evaluations of various monitoring systems (which monitor speed in addition to other potentially risky behaviors) have found that such devices can substantially reduce the prevalence of risky behaviors, particularly among teens who are most prone to risky behaviors (e.g., McGehee, Raby, Carney, Lee, & Reyes, 2007; McGehee, Carney, Raby, Lee, & Reyes, 2007; Farmer, Kirley, & McCartt, 2009).

Current Methods of Speed Monitoring

Driver monitoring devices are a relatively new concept, but the field is developing rapidly. As noted above, a broad range of inputs can be used in as the basis for providing feedback about many aspects of driver safety. Because speeding is the focus of this chapter, the approaches discussed here emphasize measurement and feedback related to speeding behaviors. It is important to note, however, that monitoring devices can measure and provide feedback in response to many other measures of safety, some of which are frequently linked to fatal speeding-related crashes (e.g., seat belt nonuse). Although there may be instances where speed monitoring is the only objective, other applications may call for a broader approach to driver monitoring.

While the measurement of speed is a necessary foundation for a speed monitoring device, some form of feedback is critical to have a positive effect on driver behavior. A wide variety of options for providing information about speeding are currently in use, and they can be grouped into three general categories:

- *Driver feedback*. The driver can receive feedback when, or shortly after, a speeding event occurs. Current systems typically use a visual and/or auditory cue to indicate when some threshold has been violated.
- *Reporting*. Information about driver performance is generated and delivered to the driver, an authority figure, or other interested party. A report could be sent shortly after an event such as speeding occurs, or could be sent on some recurring basis (e.g., weekly) to summarize previous events. Reports can include a wide variety of information, such as a detailed list of speeding events, a summary of performance, a comparison to previous reports or to other drivers, or a score that rates overall performance. Reports may be automatically compiled or generated by a person.

- *Coaching*. The monitored information could be interpreted to identify opportunities to improve behavior, which are then shared with the driver. Coaching may be most effective if video records of events are recorded, and if the coach is a diving safety professional, but some level of coaching could even be automatically generated based on a computer analysis.

The positive effects of monitoring devices on the safe driving behavior of fleet drivers and novice drivers suggest that these devices could be used in new ways to make even greater improvements in safety. While significant improvements in safety could be achieved with expanded use of these technologies in their current incarnation, even greater improvements may be achievable with additional enabling technologies.

Near-Term Uses of Speed Monitoring

Some potential near-term uses of currently available speed monitoring technologies are described below.

- *Safe driver incentive programs.* Unlike speeding enforcement, which deters speeding solely using punitive measures, speed monitoring devices also have the potential to be used as part of an incentive program that rewards drivers for safe driving. European research studies have found that the combination of speed feedback and incentives for maintaining safe speed result in reduced speeding (Hultkrantz & Lindberg, 2003; Harms et al., 2007), and NHTSA is currently conducting a similar evaluation in the United States. A variety of organizations with an interest in driver safety might be interested in sponsoring such a program, but motor vehicle insurance companies may be most motivated. Insurance companies could incentivize the use of speed monitoring devices, with the expectation that drivers who use the device are less likely to crash and therefore less likely to make insurance claims. Some insurance companies already offer pay-as-you-drive insurance, which uses monitoring technology to calculate insurance rates based in part on the amount and context of driving, which may include behaviors such as speeding. While the simple presence of monitoring technology is likely to result in improved driver safety, program sponsors could also review data for unsafe events, and perhaps offer feedback and coaching to drivers to help them improve their driving.
- *Use of speed monitoring for drivers convicted of speeding-related offenses*. Drivers who have received a speeding citation in the past three years are significantly more likely to be involved in a future crash than drivers without citations, and the likelihood of a crash increases significantly with each additional speeding violation (IIHS, 1998). Given this likelihood, offenders who are convicted of multiple or particularly egregious speeding offenses could have their vehicles instrumented with a speed monitoring device that is monitored by police personnel. While this could be perceived as a punitive use of monitoring, offenders may find it to be a preferable alternative to license suspension or other punitive measures.
- *Expanded use of speed monitoring for novice teen drivers*. Novice drivers, and particularly young males, are more likely to be involved in fatal speeding-related crashes than any other age group. Although research evidence shows that monitoring devices can reduce the speeding behavior of young drivers, their use and availability are limited. The issue of novice driver monitoring is addressed in more detail in the "Young Drivers" section of this white paper.

Future Opportunities for Speed Monitoring

Although there is great potential to reduce speeding-related crashes using speed monitoring devices as they exist today, further refinement of the technology could yield even greater benefits. Particular achievements that could yield significant benefits are:

- Improving the basis for determining the appropriateness of speed
- Implementing more assertive speed feedback or interventions

Current state-of-the-art speed monitoring devices measure absolute speed and the vehicle's location (using GPS), then compare it against a database of speed limits. Current speed limit databases, however, have limitations. They may include inaccuracies due to incorrect or outdated speed limit information, or the construction of new roads. Even if these errors are rare, they can lead to false alerts or missed opportunities to provide feedback, which could in turn decrease the validity of feedback and annoy users. Inaccurate speed limit information may also result from limitations of the GPS location measurement. While GPS location information is generally precise enough to determine the vehicle's current location, erroneous road identification can occur near intersections and when two roads are in close proximity. A weak GPS signal could also result in occasional loss of vehicle speed data (if GPS is used as the source for speed measurement). The use of speed limits as the sole basis to determine the appropriateness of speed also misses many of the nuances that can make speed particularly dangerous, such as:

- Speeding around curves and at other locations with speed advisories
- Speeding in darkness and in adverse weather conditions
- Speeding in locations with variable speed limits such as school zones or work zones
- Speeding significantly faster than surrounding traffic (speed variance)

All of the limitations described above can be addressed, and some possible improvements are described below.

- *Improve speed limit databases*. The use of speed limit databases for monitoring devices is relatively new, and some of the incorrect or incomplete information is likely to be worked out over time as device vendors refine their information. More challenging is the inclusion of speed advisory information. This information would greatly improve feedback devices' ability to provide comprehensive feedback about speed, but it is not available for current devices. Although speed advisory information is published in all jurisdictions, different agencies may record this information in different forms, some of which may not be easily integrated into a geographic information system (GIS) map database.
- *Use vehicle-based sensing of roadway conditions*. Various options exist to monitor weather and lighting conditions on roadways to determine whether speeding might be especially hazardous. One option is to use information from existing vehicle systems to indirectly assess roadway conditions. For instance, if the windshield wipers are on, it is likely that roads are wet. If the vehicle's traction control system detects loss of traction, it is likely that roads are slick. To determine more accurately whether roads are wet, a moisture sensor could be placed on the exterior of the vehicle. Moisture sensors are relatively inexpensive and they are already present as original equipment in some vehicles. If the road is wet, a monitoring device could also detect the possibility of iciness using an external thermometer. Darkness can be determined using a clock within the monitoring system, by using an ambient light sensor (either one present in the vehicle or

as part of the monitoring device), or simply by detecting when the vehicle's headlamps are turned on.

- *Use wireless technologies for roadway-vehicle communications.* Wireless communications technologies have proliferated in recent years, and they enable a vast array of opportunities for highway safety applications. While the use of these technologies for highway safety is in its infancy, major efforts are underway to begin taking advantage of the possibilities. The IntelliDrive program, sponsored by the U.S. Department of Transportation and its private sector partners, is developing technologies and applications to provide safety, mobility, and environmental services on roadways (intellidriveusa.org). Many of the capabilities envisioned by IntelliDrive will provide significant advancements for speed monitoring technologies. One major goal is to enable the roadway to provide speed limit and advisory information to vehicles, essentially ensuring that accurate and up-to-date speed information is available on roadways. This information could include variable speed limits and advisories that take into account weather conditions, school zones, work zones, and any other conditions that affect appropriate speed choice. Monitoring technology providers would not need to acquire and maintain speed databases; the information would exist within the infrastructure, and many of the condition-sensing technologies described above would be unnecessary, which could decrease the cost .of devices without losing capabilities.
- *Use wireless technologies for vehicle-vehicle communications.* Another major objective of the IntelliDrive program is to allow vehicles to communicate with each other, providing many safety benefits. Ultimately, vehicle-vehicle communications could allow vehicles to be aware of each other's presence and provide alerts or interventions to prevent conflicts and collisions. For speed monitoring applications, vehicle-vehicle communications could enable the determination of vehicle speed relative to the speed of surrounding traffic (speed variance), which is an indicator of inappropriate speed and crash risk (Aarts & van Schagen, 2005).

Advanced speed monitoring technologies can also include improved and more assertive methods of feedback. As noted earlier, current methods of feedback typically take the form of immediate feedback to the driver or summary reports delivered to the driver or an authority figure, which can be used as the basis for guidance or coaching. To date, a number of variations on these themes have been implemented, and while some have shown advantages over others (e.g., Farmer, Kirley, & McCartt, 2009), no clear "best practices" have emerged. Additional experience and research is likely to provide further evidence of approaches that work well for particular applications of speed monitoring. Beyond current practice, however, there are potential new approaches that could yield additional benefits:

- *Implement more assertive in-vehicle feedback and interventions.* As mentioned earlier, current speed feedback devices are prone to occasional erroneous information about speed limits and typically lack a good deal of contextual information that could be used to more accurately determine the appropriateness of speed. One result of this limitation is that monitoring devices generally do not provide particularly assertive feedback to drivers to allow for the possibility that alerts are erroneous or not particularly urgent. More precise speed information could allow for alerts that are more sensitive to context and urgency. Alerts could be staged to correlate with risk (i.e., gentle alerts for moderate risk and assertive alerts for high risk). Similarly, feedback devices could integrate

vehicular interventions to discourage or prevent risky actions. These could include lockouts of convenience and entertainment features (e.g., stereo system, wireless communications) or interventions to directly reduce risk (e.g., accelerator force feedback, automatic braking, or speed limiter). For vehicle interventions, it is particularly important to consider human factors design principles to ensure that these features do not inadvertently increase risks. Wireless communications technologies could also enable monitoring devices to automatically alert police agencies about speeding, or even to automatically issue speeding violation notices. This type of application could be particularly useful if speed monitoring devices are mandated for use by drivers convicted of speeding-related offenses.

- *Implement proactive feedback*. The presence of geographically accurate speed limit and advisory information enables the use of proactive feedback to alert drivers to risky locations before they encounter them. Feedback could be generic (e.g., indicate need to slow down ahead) or specific (e.g., indicate the specific condition that warrants the alert, such as a sharp curve ahead). Condition-specific feedback may require the use of voice alerts. Vehicle interventions could also be used proactively to prevent unsafe behaviors.

While speed feedback devices offer great potential to reduce speeding-related crashes, there are challenges in achieving optimal use and benefits. Privacy concerns are often a limitation to public acceptance of monitoring (Lerner et al., 2009). Users may be concerned that monitored information may accessed by unauthorized parties or used in ways that they do not approve of. Monitoring device providers must ensure the security of data, and inform users of how information will be used. Users should also be informed if there is a possibility that monitored information could be subpoenaed for legal proceedings, for instance, if the vehicle is involved in a collision while a monitoring device is functioning. Device tampering is another concern, particularly if a monitoring device is installed against the will of the user (e.g., mandated by a court). Devices should be designed to resist tampering. Another potential challenge is that current vehicles have a single OBD-II port from which vehicle performance data can be acquired, but as in-vehicle technologies proliferate, speed monitoring devices may be just one of multiple devices that require data port access. Finally, to achieve widespread use of speed monitoring technologies, stakeholders who are important to the implementation and success of these technologies must realize the benefits of monitoring and become active partners in their use. Some factors that might encourage stakeholders to support speed monitoring include:

- Further evidence of the safety benefits of monitoring through successful implementations and scientific evaluations.
- Advances in technology that enable improved functionality and reduced costs.
- The presence of initiatives such as IntelliDrive that are seeking to implement the infrastructure and vehicle technologies that will be the backbone for advanced monitoring functions, drastically reducing the costs and efforts to implement advanced monitoring features.

Use Automated Speed Enforcement Technologies to Achieve Broad Area Enforcement

Current ASE programs in the U.S. generally limit the use of ASE to certain types of roads and certain locations, and use spot enforcement that measures speed at a single location. Many jurisdictions also use permanently fixed ASE units that offer the benefit of 24-hour enforcement, but at the cost of making the locations of enforcement predictable to drivers. Predictable

enforcement locations are likely result in minimal speeding deterrence outside of enforced areas (Elliott & Broughton, 2004). While ASE programs have generally been successful in reducing speeding (Pilkington & Kinra, 2005), greater benefits may be achieved by using methods and technologies that achieve enforcement and deterrence over a broader area. Broad area enforcement may also help to change the public's attitudes toward speeding and speeding enforcement. By applying ASE broadly in a way that deters speeding throughout the area, adherence to speed limits could become the norm, making speeding a more conspicuous behavior, so that speeding drivers are more self-conscious of their behavior. Broad area enforcement may also help to dispel driver perceptions of speed traps: locations that are frequently enforced because drivers often exceed the speed limit, whether or not there is a safety problem. Approaches to achieve broad area ASE are discussed below.

- *Expand use of mobile ASE*. Mobile speed enforcement, in which enforcement units are moved between various locations, reduces the predictability of enforcement and can broaden the deterrent effect of ASE (NHTSA, 2008b). To maximize the effects on speeding and related crashes, mobile ASE should be present on a wide variety of roads, with an emphasis on locations and road types where speeding-related crashes are most prevalent. Signs placed on enforceable roads indicating that speeds are enforced by camera may also deter speeding. Covert enforcement, in which enforcement units are not clearly marked, can also help to reduce the deterrent effect of ASE by making drivers less confident in their abilities to spot enforcement units in advance. When using covert enforcement, it is especially important to promote public awareness of enforcement through signage and information campaigns (NHTSA, 2008b).
- *Implement point-to-point ASE*. Also known as "average speed" enforcement, point-to-point ASE detects a vehicle at two different points along a roadway system and determines the vehicle's average speed by calculating how long it took to travel between the two points. Point-to-point enforcement moves away from the typical roadside speed enforcement model in which speeds are observed at a single point, and allows speeds to be enforced over an expanse of roadway. As such, it allows authorities to detect and cite sustained speeding rather than a single moment, which could potentially result from a momentary lapse of attention to speed or a brief maneuver (e.g., overtaking). On the flip side, however, because point-to-point ASE only measures average speed over some distance, it cannot account for drivers' speeds in particularly hazardous locations, such as around curves, where speeding-related crashes are overrepresented. Point-to-point ASE is most likely to be effective when there are few or no traffic control devices to prevent traffic from maintaining cruising speed. This means that point-to-point ASE is typically most appropriate on limited access highways (e.g., freeways) and rural roads with free flowing traffic. The use of point-to-point ASE on rural roads could be especially beneficial because these roads account for a substantial number of speeding-related fatalities, and because current ASE programs rarely conduct enforcement in rural areas. One challenge of conducting any type of ASE in rural areas, however, is that the systems might be particularly prone to vandalism in areas with few people around. While most point-to-point ASE implementations have used a single entry and exit point, some recent implementations use a network of detection cameras to enable enforcement of many routes (Webster, 2009). (For example, a driver who passes through detection point A could have their average speed calculated whether they next pass through exit point B, C, or D.) Current point-to-point systems match vehicles using license plate image capture,

but improved vehicle and infrastructure communications technologies may soon make feasible other forms of vehicle identification.

IMPACT, COSTS, AND FUNDING

The table below summarizes the suggested initiatives to reduce speeding-related crashes and fatalities.

Table 2. Initiatives to reduce speeding-related fatalities.

STRATEGY	AIMED AT	POTENTIAL FATALITY REDUCTION	WHO BEARS COST	COSTS (IMPLEMENT/ MAINTAIN)	OBSTACLES TO IMPLEMENTATION
Expand the Use of In-Vehicle Speed Monitoring Technologies	All fatalities involving speeding.	Potential reduction depends on degree of fleet penetration and type of intervention. 12,000 speeding-related fatalities; 25% reduction would save 3,000 lives annually.	Varies by implementation model. Some enabling technologies and infrastructure are being developed by USDOT. Some costs may be recovered due to crash reductions.	Device costs vary depending on features, but current commercially available devices are typically $300-$1500 per unit. Future applications may cost much less if they use technology already present in the vehicle and infrastructure.	Privacy concerns, information security, need for agencies/companies to initiate monitoring programs.
Use Automated Speed Enforcement Technologies to Achieve Broad Area Enforcement	All fatalities involving speeding.	12,000 speeding-related fatalities; a 5-10% reduction in fatalities across U.S. could save 600-1,200 lives annually.	Implementing agency. Some costs may be recovered through violation fines.	Equipment costs are high; lease arrangements for equipment and services are more common than purchases.	Public and political opposition to monitoring, legal restrictions on conditions of enforcement, lack of clear data on effectiveness of various ASE strategies to support decisions.

REDUCE DRIVER DISTRACTION

RECENT TRENDS IN DISTRACTED DRIVING FATALITIES

According to a recent report from NHTSA (2009), distracted driving was a factor in 5,870 fatalities in 2008. Figure 4 shows a trend of distracted driving related fatalities from 2004 to 2008. It appears that these fatalities have increased from 4,980 in 2004 to 5,870 in 2008. NHTSA admits that "measuring driver distraction in the field is difficult and potentially imprecise because of self-reporting and timing of data collection." Despite that caveat, the data in Figure 4 represents the best-known information available on the fatal effects of driver distraction.

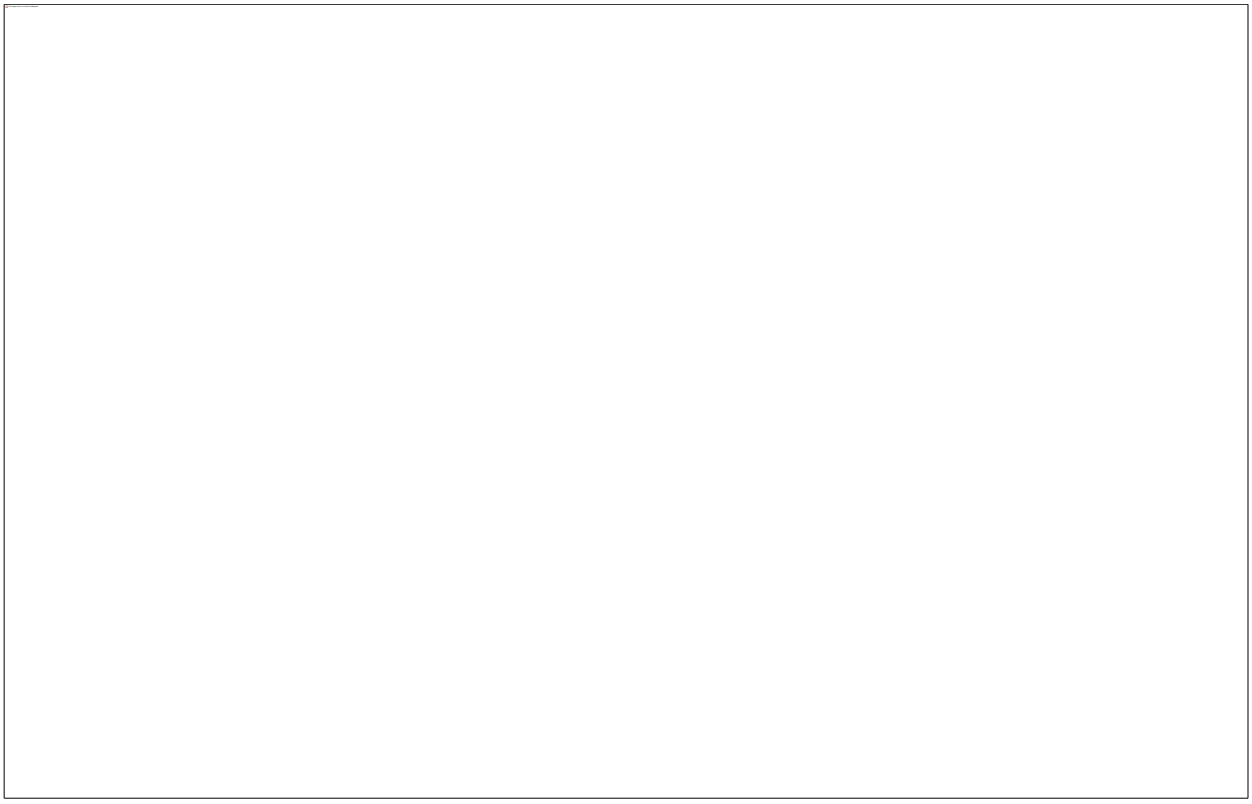

Figure 4. Trend of fatalities from crashes involving distracted driving.

Driver distraction has become a very prominent issue in recent years. This is highlighted by the high visibility actions of Secretary of Transportation Ray La Hood in personally championing this cause (U.S. Department of Transportation, 2010a) and media star Oprah Winfrey making this a public issue with her "No Phone Zone" pledge campaign (Oprah.com, 2010). The explosive growth in the use of personal communications devices, the increasing presence of more complex technologies in vehicles, the rapidly expanding range of consumer-available applications, and the development of evolving new technologies and services have made the potential threat of this problem quite evident to many policy makers and researchers, and even the general public.

Most of the current discussion and research has focused on distraction from in-vehicle driver activities, most especially on technology use. This is an appropriate major focus, given the prominence of cell phone use as a distracter and the explosion of personal communication

devices and applications that may potentially be used during driving. Much less attention has been given to distraction sources external to the vehicle. Here too, however, technology changes are raising enhanced concern about driver distraction. Display technologies for on-premise and off-premise commercial signing now make feasible large, bright dynamic signs capable of full color, pictures and graphics, motion and video, and rapid changes of display. It is very difficult to objectively identify and quantify the distracting effects of such displays, although there has been some research (e.g., Chattington, Reed, Basacik, Flint, & Parkes, 2009; Molino, Wachtel, Farbry, Hermosillo, & Granda, 2009) and the FHWA is currently exploring this problem.

REDUCE DRIVER DISTRACTION STRATEGIES

Strategies for reducing driver distraction crashes may be grouped into three broad categories:

- Strategies to prevent or limit the occurrence of driver distraction
- Strategies to detect and respond to incidents of driver distraction
- Strategies to compensate for the effects of driver distraction.

The strategies to prevent or limit the occurrence of distraction include initiatives related to legislation and enforcement, education, and design improvements of potentially distracting products. The strategies to detect distraction would encompass technologies and models to recognize distraction directly (e.g., eye glances, physiological indices), indirectly (e.g., through driver vehicle control, such as steering inputs, lane positioning, and headway), or by engagement in distracting tasks (e.g., cell phone use). Strategies for mitigating the effects of distraction involve the use of intelligent crash warning systems, automated vehicle control actions (e.g., crash-imminent braking), and roadway countermeasures (e.g., clear zones, median barriers, and edge treatments). For this third class of strategy, the countermeasures are more appropriately addressed in the white papers on Safer Vehicles and Safer Infrastructure, and are not included as part of this Safer Drivers white paper.

There are three interesting and unique aspects about the driver distraction issue that raise special considerations for the implementation of effective safety initiatives. One unique aspect is that many of the causes and potential countermeasures lie outside the direct authority of transportation agencies. Nomadic and aftermarket devices that drivers may use in the vehicle may not be within NHTSA's regulatory scope. In-vehicle technologies may use components and information provided by companies that have little or no experience in the automotive field, and nomadic devices may not be designed with the vehicle environment in mind at all. Outdoor commercial signing may be regulated to some degree by highway authorities and local codes but regulation of these codes is limited. Many non-technology in-vehicle sources of distraction are not addressed by roadway or vehicle design and operation, such as interacting with children, eating or drinking, pets, and other personal activities. These limitations of authority certainly have implications for safety initiatives, since they may require cooperation from entities outside the safety community and from drivers themselves. A second unique aspect is that the development of potentially distracting technologies continues to race ahead of research, regulation, and legislation. Consumer products and applications (particularly personal devices, as opposed to vehicle original equipment) may be several generations ahead of the formal efforts to deal with the problems. For example, while research and legislation are still being done on phone conversation, they are only beginning on text messaging, and other new or emerging applications may not even be in our current framework (e.g., social networking, augmented reality displays, hand-held video conferencing). We therefore face the problem of "fighting the last war" when

we may not even be able to well-imagine the technology world that is just around the corner. A third unique aspect is that there is typically no physical evidence of the occurrence of distraction. It may be very difficult for enforcement personnel to objectively observe and document and there is no "test" for driver distraction after a crash or a traffic stop. All of these unique characteristics of driver distraction impose challenges for addressing the problem.

In the subsections that follow, we provide an overview of some of the major areas of activity being pursued to address driver distraction crashes. Next, we introduce a suggested set of particularly promising initiatives. These selected initiatives are promising as steps toward "zero deaths" in that they are currently not widely implemented or adequately refined, but have good potential to reduce distraction crashes.

Distracted Driving Laws, Policies

There has been a great deal of recent activity in laws and policies related to distracted driving. These laws may apply to specific technology use (e.g., hand held cell phones), specific tasks (texting), engaging in distracting activities more generally, particular driver groups (teens, bus drivers, government vehicles), or particular locations (e.g., school zones). A good recent summary of State laws related to cell phone and texting may be found in the web site for the Governors Highway Safety Association (June 2010a). Since legislation may be active in many States, the numbers only represent a snapshot at the time of this review. An interesting aspect of the summary is that no State has an outright ban on all (non-emergency) cell phone use while driving. Seven States plus the District of Columbia and the Virgin Islands ban handheld phone use. A majority of States include some restriction for novice drivers (28 States and the District of Columbia). Texting is explicitly banned for all drivers in 28 States, the District of Columbia, and Guam. The majority, though not all, of these laws are primary enforcement laws. Despite the attention these laws are drawing, there does not appear to be a parallel emphasis on intensive enforcement. However, some innovative pilot enforcement programs are now underway (Governors Highway Safety Association, 2010). Another growing policy is the requirement to collect information on distraction in police reports. Thirty-four States, the District of Columbia, and the Virgin Islands now require a category on cell phone use or other distraction within police accident report forms, and there is proposed federal legislation related to this as well.

While there has been a great deal of activity for laws on in-vehicle technology use, there has not been comparable concerted activity for dealing with new technologies for external roadside displays that may be distracting. There is a "large and growing number" of State and local regulatory documents in the U.S. (Wachtel, 2009), but wide variability and no cohesive strategy. Wachtel provides a good review of U.S. activity as well as foreign practice.

Technologies for Detecting Distraction

Driver distraction has been the focus of a great deal of recent research, and this includes the development of technologies for detecting when the driver is distracted. NHTSA's SAVE-IT program represents a good example of this type of research (Smith, Witt, & Bakowski, 2008). Driver distraction can be sensed or inferred from vehicle control actions, overt behavior (e.g., looking, manipulating, posture), detection of technology use, or physiological indices. Such research has yet to find its way into passenger vehicle systems, although some manufacturers have developed systems that track when the driver's face is not aimed at the forward roadway, or track position of the vehicle within lane boundaries as a surrogate for inattention. When

distraction is accurately sensed, this information could be used in various ways: real time warnings, post-drive reports, suspension of access to secondary tasks (e.g., phone or infotainment system lockout), or direct intervention in vehicle operation (e.g., speed limiter).

Guidance and Standards for Design of Devices and Displays

Driver distraction can be reduced if products are designed to be more compatible with the driving task. The automotive industry is actively working on standards related to distraction, such as design principles or evaluation methods. Standards and professional organizations doing this include the Society of Automotive Engineers, the Alliance of Automobile Manufacturers, and the International Organization for Standardization. NHTSA is also active in research related to design and evaluation to minimize distraction. However, one of the important aspects of this problem is that many of the distracting devices and activities do not come from functions provided by the automobile manufacturer. The telecommunications and computer industries are important providers of devices and services and they are much more diverse and less directly regulated than the automotive industry.

Public Awareness and Education

There are numerous efforts to improve public awareness of the hazards of distracted driving and the appropriate behaviors to deal with this. Many States have developed educational materials as well as new sections for their driver's manuals and driver training guidelines. An overview by the Governors Highway Safety Association (2010) indicated that 41 States and the District of Columbia have conducted or are conducting public education and information efforts and many of these are taking advantage of social networking sites. Insurers (e.g., Allstate), safety advocacy groups (e.g., AAA Foundation for Traffic Safety), employers (e.g., Network of Employers for Traffic Safety), and health care providers (e.g., Children's Hospital of Philadelphia) all have developed campaigns and materials.

PROMISING INITIATIVES

Six initiatives are identified here as promising approaches to substantially reduce distraction-related crashes. Each initiative may involve multiple activities. The suggested initiatives are:

- Promote effective enforcement of distracted driving laws
- Foster change in driver attitudes about multitasking risks and responsibilities
- Support technology developers in the design of devices, tasks, interfaces
- Target teen drivers
- Develop adaptive driver interface systems
- Develop and implement criteria for the design and use of digital outdoor commercial signage

Promote Effective Enforcement of Distracted Driving Laws

Although laws against cell phone use or text messaging now have been enacted in numerous States (Governors Highway Safety Association, 2010), there is poor public compliance and little perceived likelihood of receiving a citation (AAA Foundation for Traffic Safety, 2008). People appear to acknowledge that there is risk in multitasking (at least for other drivers) but that everyone does it and it is tacitly OK (Braitman & McCartt, 2010). The history of public response to various legislative changes regarding cell phone use laws often has been one of initial decline

in phone use followed by a return to higher levels. The absence of effective enforcement appears to be a contributor to public behavior with regard to distracted driving. While it is commonplace to observe cell phone use and other distracting activity in surrounding traffic, there is little visible enforcement and probably a low perceived risk of being cited. A number of steps could be taken to make enforcement more effective:

- *Comprehensive primary enforcement laws*: Although many States have some form of law regarding certain forms of communications technology use, these are not uniformly primary enforcement laws and do not comprehensively cover all forms of activity (Governors Highway Safety Association, June 2010a). No State bans all cell phone use for all drivers. Some ban only handheld phones or only texting or limit cell phone bans to certain classes of drivers (e.g., novice drivers, school bus drivers) or locations (school or construction zones). A number of States have no restrictions at all. Most restrictions are primary enforcement laws but some (particularly texting and novice driver restrictions) are secondary. Limiting restrictions to only certain drivers or activities suggests a tacit approval of other conditions of phone use while driving. Uniform primary laws prohibiting all cell phone use would make enforcement more consistent and promote the desired message that all non-emergency use of communications technology while driving is undesirable.
- *High visibility enforcement and coordination with public information and education*: Experience with other highway safety issues has shown the benefits of well-publicized high visibility enforcement campaigns, coupled with public information and education programs. Click It or Ticket seat belt campaigns and alcohol checkpoint programs represent models that may be applied to driver distraction. There are a few initial efforts at visible enforcement underway, including Connecticut Department of Transportation and New York Department of Motor Vehicles pilot programs modeled on Click It or Ticket (Governors Highway Safety Association, 2010).
- *Detection and documentation of technology use*: Police investigation of crashes may not be effective in uncovering cases of distracting technology use and often must rely on questionable driver self-report or witness statement. Unlike crashes involving alcohol or speed, there is typically no physical evidence after the crash to implicate the distracted driver. The role of distracting activities in serious crashes is likely to go undetected, unprosecuted, and unreported by media. It would be useful to develop effective tools, procedures, and policies for more routine determination of illegal use of cell phones or other prohibited technology use. This may require better access to individuals' cell phone activity records. It also has implications for the consideration being given by NHTSA and others to standardizing requirements for vehicle event data recorders. EDRs are currently not required, vary among automobile manufactures, and their data are not easily accessed. Future EDRs may warrant inclusion of data regarding technology use or driver inattention, as well as a standard clock time so that crash occurrence can be synchronized with external data sources, such as cell phone use records. In addition to devices that may help document device use after the crash, there are also potential technologies for detecting phone use by drivers in traffic. Developers of cell phone detection technology appear to be primarily oriented to security applications (e.g., Bloodhound and Wolfhound detectors, http://www.bvsystems.com/Products/Microcell/Bloodhound/bloodhound.htm?gclid=CNOT3MOvuaICFYM65Qodtxhy6Q) and we have not seen viable products for

traffic enforcement. However, if a market for traffic enforcement appears significant, this technology can probably be adapted to that application.

Foster Change in Driver Attitudes about Multitasking Risks and Responsibilities

There is a general public tolerance for driver multitasking, particularly for oneself (Braitman & McCartt, 2010). The public is not unaware of the risks, and consider this a significant safety problem. Public education about the hazards may be helpful, and numerous efforts are being made at this (e.g., Governors Highway Safety Association, 2010), but it does not appear to be the crux of the problem and such education campaigns typically do not have sustained impact (NHTSA, 2010; Stutts et al., 2005). Whether because they feel they have superior abilities or because the find the risk acceptable, many drivers are unwilling to modify their own multitasking behavior.

As noted by various reviewers (e.g., Caird & Dewar, 2007), a more basic shift in social norms is required, such that phone use and other distracting activities are seen as socially unacceptable and stigmatized. This will not be achieved simply by promoting a better public knowledge of the risks. A shift in the norms of acceptability undoubtedly will be difficult to achieve, given the strong counter-trends in our society toward multitasking, social networking, and staying "wired." Parallels with the success of societal shifts in the tolerance for drink driving have been made and experience in the alcohol area should certainly be closely studied for strategies that can be adapted. We would also suggest that any efforts to change the public perception of distracted driving norms will require parallel efforts in enhanced enforcement to be successful. Since all of us routinely witness instances of distracted driving, yet rarely experience any enforcement, the implication of societal tolerance is inherent.

One approach to consider is targeting efforts not to the driver, but to others who may exert social influence on the driver. This could include passengers, the other party communicating with the driver, pre-driving age children, employers, or health care providers. It may be easier to get people to act when they are in a non-driving mode than when they are drivers themselves.

Victims groups, such as Mothers Against Drunk Driving (MADD), have been cited as important contributors to the change in public acceptance of drink driving. For distracted driving, while testimonials from grieving families or atoning drivers have occurred, and certainly have emotional impact, such groups do not appear to have gained traction. Perhaps this is due in part to the low visibility of distraction-related fatalities. Media coverage of traffic deaths frequently allude to the presence of alcohol, high speed, or non-use of seat belts. Perhaps greater media involvement in routine reporting might contribute to the shift in norms as well.

It may also be helpful to work from the perspective that multitasking is not a driving issue but a lifestyle issue and the solutions may more generally related to norms regarding how time is used, what is "wasted" time, and how we interact socially.

Support Technology Developers in the Design Of Devices, Tasks, Interfaces

Increasingly, the developers of technology devices and services that may be used in the automobile are not the companies and industries that have traditionally designed products for safe use while driving. The automotive industry and automotive regulators have extensive experience, as well as an established responsibility, in this area. Standards groups and industry associations affiliated with the automotive industry, such as SAE, ISO, and the Alliance of Automobile Manufacturers are all developing guidelines relevant to the safe use of their in-

vehicle technology. A good example is the "Statement of Principles, Criteria and Verification Procedures on Driver Interactions with Advanced In-Vehicle Information and Communication Systems" from the Alliance of Automobile Manufacturers (2006). The guidance, standards, and regulations developed within the automotive community may not inform or be fully appropriate to those companies and industry groups that design aftermarket products, nomadic devices, and software applications that may be intended for, or simply used by, consumers who are driving. Cell phone applications provide a very good illustration of this concern. For instance, while automobile manufacturers may carefully design original equipment navigation systems with displays, input controls, and lockouts for safe use while driving, someone unfamiliar or unconcerned with the issues may develop a navigation application for a handheld device that is quite inappropriate for use by drivers.

The suggested safety initiative is based on the recognition of this important shift in the community of enterprises that brings distracting technology to the vehicle. It is critical to encompass these "outside" groups and individuals within efforts to control the technology interfaces that influence distraction. Activities may include:

- *Design guidance for developers of technology that may be used in vehicles*: Because new devices and applications will always be well ahead of our ability to evaluate, regulate, and legislate, it is important that product developers unfamiliar with driver and highway safety issues have tools to help them from the outset. The experience of the vehicle design and driver behavior communities has established specialized expertise that should be adapted to the needs of personal communications technology designers and programmers. The effort should also include collaboration between industry standards organizations.
- *Product certifications and consumer information*: Assist consumers in the purchase and appropriate use of nomadic and aftermarket devices. This can be done through the development of programs for labeling, rating, or certifying products in terms of usability while driving. A ratings program could also motivate product designers to incorporate safer user interfaces.
- *Regulation and oversight*: Establish cooperative working relationships between automotive regulatory agencies and other government agencies with oversight of other technologies, products, and communications. The distinction between the vehicle, the roadway, personal products, and communications technologies is now blurred and the regulatory and oversight structure may not be comprehensive or coordinated. Driver distraction and crash reduction may not be significant issues or responsibilities for agencies that more directly influence technology providers. Therefore some form of on-going relationship or working group should be developed to insure that traffic safety considerations are properly integrated with the many complex parallel concerns with technology and communications services.

Target Teen Drivers

Teen drivers should specifically be the target of a distracted driver initiative. In addition to the exceptionally high fatal crash rates this group suffers, they merit special attention because as a group they are avid technology users, frequent multitaskers, have poorer decision-making and vehicle control skills, overrate their abilities for both driving and multitasking, and are in the

process of forming driving habits which may influence their driving style and crash risk for years to come.

Other reviewers of this problem (e.g., Stutts et al., 2005) have highlighted the needs for incorporating cell phone use restrictions into Graduated Driver Licensing programs and educating young drivers about the risks of distracted driving. According to the Governors Highway Safety Association (June 2010a), 28 States and the District of Columbia have recently moved to include restrictions on cell phone use within the GDL program, and most of these are primary enforcement laws. Many States still do not provide sections on distraction in driver licensing manuals or other educational materials aimed at teens or parents. While GDL restrictions and educational materials still must become more widespread as generally needed measures, more specific refinements are highlighted here as key initiatives to further reduce deaths.

- *Enforcement and adjudication of GDL provisions*: Although GDL restrictions may be primary laws, they are difficult to enforce because police cannot be sure if a young driver is a novice under the age of 18. There have been suggestions to identify vehicles operated by teens by means of some form of visual tag or decal, but these have met with considerable public resistance (e.g., Wall Street Journal, 2010). Among the problems are perceived threats to teen security and the issue of household shared vehicle use. Another problem with these laws is that if there is a requirement for some form of hearing before GDL penalties are put in place, that period may be relatively long relative to the GDL age limit itself., since a teen may "graduate" from GDL requirements at age 18. Efforts must be made to promote effective enforcement and immediate consequences. As part of this, government and industry should consider the development and use of a "smart key" for teen drivers. Smart keys, which can be set to customize vehicle features for particular drivers, are already a feature for some vehicles, and the Ford MyKey system specifically addresses teen drivers. If GDL programs included a universal smart key for novices, it may be possible for enforcement personnel to identify teen drivers without a publicly visible tag and without characterizing the vehicle as a teen vehicle.
- *Driver training and education*: There is a need to focus more strongly on driver skills for managing distraction, not just "awareness." Training modules need to provide strategies and drills for dealing with distractions. For example, these might include the use of pre-programming features for devices such as navigation systems and cell phones (ring designations); dealing with distracting peer passengers (teen passenger presence is an extremely important risk factor in teen crash risk); and responding appropriately to incidents and errors (e.g., spilled drinks, input entry errors); finding and maneuvering to safe areas to stop and return calls.

Develop Adaptive Driver Interface Systems

Drivers have the ultimate responsibility to maintain attention but this does not preclude developing vehicle capabilities that assist and correct drivers when distraction occurs. Vehicles increasingly have the power to sense and interpret information related to driver distraction. This includes information about vehicle actions, driver state, ongoing driver activities, interacting traffic, and surrounding roadway features and conditions. This information can be used to manage driver workload and maintain driver attention. An adaptive vehicle interface system can warn distracted drivers, limit distractions and competing information at times when the driver is

distracted or overloaded, and modify the vehicle response itself (e.g., limit speed, increase headway). NHTSA and others have conducted research on adaptive vehicle interfaces and some rudimentary systems are available in production vehicles. This initiative is to continue this line of R&D effort in order to develop commonplace vehicle capabilities that will help keep the driver out of threatening distracted driving conditions. (We contrast these systems with crash avoidance functions that warn or intervene in an impending crash situation; see Safer Vehicles white paper). NHTSA provided an important step in this direction with the SAVE-IT (SAfety VEhicles using adaptive Interface Technology) program (Smith, Witt, & Bakowski, 2008), which was a large scale proof-of-concept study begun in 2003. Technology has improved significantly since then and the IntelliDrive program can be expected to bring even more capability. The area that may need the most new focus is in the ability to recognize the driver state of distraction. Practical capabilities for assessing glance behavior and remote sensing of physiological indices would be important advances. The integration of various sources of information to derive a reliable index of distraction threat and strategies (warnings, interventions, lockouts) to address it will have to be validated. The SAVE-IT program also identified benefits to a post-drive summary of safety-relevant events and behaviors (trip report), which was effective at improving driver responses to events on subsequent drives. The objective of this initiative is to ultimately provide all drivers with intelligent adaptive systems that can help them manage attentional demands and limit distraction.

Develop and Implement Criteria for the Design and Use of Digital Outdoor Commercial Signage

Although the magnitude of the safety problem associated with distracting outdoor commercial signage is very difficult to estimate, the technical feasibility and falling cost of large, bright, dynamic signage is expanding the implementation of such signs for both off-premise and on-premise applications (Wachtel, 2009). There is increasing evidence of the distraction potential of such signs (e.g., Chattington et al., 2009). FHWA provides some control over off-premise signing through the Highway Beautification Act. On-premise signing generally has more leeway and is primarily controlled by local zoning codes. In addition to these fixed commercial sign applications, there are also vehicle-based digital signs which can be moved from location to location and can even present fairly large digital sign displays while traveling in traffic. The growth of digital sign technology and the spread of the applications suggest that safety initiatives be put in place before their presence is ubiquitous.

Controlling potentially distracting commercial digital displays is difficult and controversial for a variety of reasons, including issues of free speech, local control, and commercial enterprise. There is vocal industry resistance to characterizations of the distraction problem as well as to various proposals for restrictions (e.g., Crawford, 2010). There is an inherent tension between the intent of commercial signing to draw viewer attention and the goal of roadway authorities to ensure that signage is legible, quickly comprehended, and relevant to the driving task. Although the impact on traffic crashes and fatalities is not well-quantified, the concern is that once these signs become ubiquitous, it will be even more difficult to manage their use once a significant problem is quantified.

The suggested initiative is to develop a clear set of objectively-based criteria for the design and use of digital signs, which will then serve as a basis for regulation by various levels of government as well as voluntary industry standards. Comprehensive criteria must include the following:

- *Luminance*: The brightness of digital signs is a key characteristic that distinguishes them from traditional billboards and enhances their ability to draw attention. Currently there is not agreement on what a maximum luminance level should be, and in fact, there is not even agreement on how digital sign luminance should be measured. A standard measurement method is required and upper limits for luminance must be defined for day and night conditions.
- *Placement*: The distraction risks of a digital sign depend on where it is placed, including considerations of roadway geometry, traffic, driver workload, and surrounding environment. Various foreign efforts provide a good model for how more strict and rational criteria can be provided for placement (Department of Main Roads, 2010 in Queensland, Australia).
- *Message change frequency*: A dynamic change from one display to another can draw attention. A frequent rate of change may approach the concept of "flashing," but even less frequent changes can promote continued refocusing of attention on the sign and away from the road. Some have argued that the minimum rate of change should be such that a driver encountering the sign will not see more than one message change (taking into account sight distance, sign legibility, vehicle speed, etc.).
- Sign content: Features of the message itself will influence how distracting it may be. This includes considerations such as the amount of information, the amount of contrast for text and background, fonts and the range of font sizes, pictures, and so forth.
- Message sequencing: Digital signs can be used to provide a complex message that spans more than one display. Messages that require the driver to attend to a sequence of displays may require additional attention.

An initiative to provide effective and accepted criteria and regulation for digital commercial signing will require cooperative efforts from regulators, legislators, sign industry groups, and the business community, as well as expertise in the design of displays and the human factors of sign use by drivers.

IMPACT, COSTS, AND FUNDING

The table below summarizes the six suggested initiatives for driver distraction. The column for Potential Fatality Reduction is left open because there are no reasonable estimates for the total number of fatal crashes attributable to distraction, or the subcategories such as internal versus external distracters, phone use versus other activities, technology use versus non-technology. Although estimates have been made, they are highly variable. For example, NHTSA's CDS data (discussed in Stutts et al., 2005), coded 6.6% percent of drivers as "distracted." But only 39.15 were coded as "attentive;" 46.3% were "Unknown,Other." Caird and Dewar (2007) reviewed a number of studies on this issue and numbers can be extremely different depending on definitions and methods. It may be noted that the 100-car naturalistic driving study (Dingus et al., 2006) found that the driver looking away from the road was a frequent precursor to crash and near-crash events. NHTSA (2009) also discusses the range of issues in deriving an estimate. Even if some good estimates of this were available, they would likely soon be outdated due to the rapidly evolving world of consumer telecommunications and computer technology. Therefore while reasonable estimates are not available and not shown in the table, we can recognize that distraction is a major factor in fatal crashes, likely to be at least in the 15-25% range.

Table 3. Initiatives to reduce driver distraction.

STRATEGY	AIMED AT	POTENTIAL FATALITY REDUCTION	WHO BEARS COST	COSTS (IMPLEMENT/ MAINTAIN)	OBSTACLES TO IMPLEMENTATION
Promote Effective Enforcement of Distracted Driving Laws	Fatalities associated with cell phone use or texting while driving		Industry costs associated with EDR requirements	Costs of developing EDRs and including in future vehicles. Costs of enhanced enforcement borne by violators.	Privacy and data rights issues; political acceptance of stricter laws
Foster Change in Attitudes About Multi-Tasking Risks and Responsibilities	All fatalities associated with driver multi-tasking		Program implementers (public or private)	Program development, evaluation, and sustained implementations	Broader societal attitudes about multi-tasking, social networking, and use of personal time
Support Technology Developers In The Design Of Devices, Tasks, Interfaces	Fatalities associated with distracted driver use of in-vehicle technologies		Automotive and technology industries, government research and regulatory groups	Costs of product testing and certifications	Political issues of government agency cooperation, regulation; consumer demand for unrestricted access to new applications
Target Teen Drivers	Fatalities in crashes involving teen drivers who are multitasking with technology while driving		Technology development costs to industry and government, programs of driver training	R&D costs to develop and implement smart key technology; development of new driver training components	Parental and teen acceptance; OEM perceptions of market demand
Develop Driver Assist Systems	Depending on level of sophistication, potentially all distraction-related crashes		Technology development costs to industry and government, consumers	R&D costs to advance current products. Additional costs in equipped vehicles	Potential cost and complexity of reliable systems; consumer acceptance if felt to be intrusive
Develop and Implement Criteria for the Design and Use of Digital Outdoor Commercial Signage	Fatalities associated with distraction from electronic outdoor commercial signs		Needed data collection to support revised sign criteria	No costs to sign industry or local authorities. Costs of research to establish appropriate objective criteria	Industry and political resistance to restrictions on commerce. Absence of direct evidence of distraction-attributable crashes

INCREASE SAFETY OF YOUNG DRIVERS

RECENT TRENDS IN YOUNG DRIVER FATALITIES

Young driver related fatalities (crashes where one driver was aged 15-20 years) have been on a gradual downward trend since 2004, beginning at 8,780 in 2004 and ending at 6,428 in 2008 (NHTSA, 2009e). This reflects a total decrease of 26%. The sharpest annual decrease in the absolute number of fatalities was seen from 2007 to 2008, most of which could be attributed to the nationwide drop in fatalities that was experienced in 2008. However, as seen in Figure 5, the percentage of young driver fatalities of all fatalities decreased as well, falling from 18.7% in 2007 to 17.3% in 2008. This indicates that some progress was made in the area of young driver safety above and beyond the nationwide decrease in fatalities.

This progress may be due to States implementing stricter graduated driver licensing (GDL) programs or other safety focused programs. Some speculate that rising gas prices in 2008 may have decreased the number of miles driven by young drivers, under the reasoning that young drivers have less income and would be disproportionately affected by higher gas prices. Other speculation is that youth culture has become increasingly virtual; as friends spend more time connecting with each other over computer networks and cellular phone networks, physical travel has been reduced. However, this speculation is difficult to discuss, since there is currently no good source of annual exposure data on young drivers.

Figure 5. Fatality trend of young driver (15-20 years) crashes.

Despite the downward trend in fatalities, motor vehicle crashes remain the leading cause of death for teenagers in the United States, and the number of fatal crashes (in which one or more people

lose their lives, including passengers, other drivers, pedestrians, etc.) per 10,000 licensed drivers is twice as high for the age group 16-20 as compared to adult drivers (NHTSA, 2010).

STRATEGIES FOR REDUCING FATAL CRASHES INVOLVING TEEN DRIVERS

Various strategies for reducing crashes involving young drivers have been implemented or proposed. These may be grouped into four broad categories:

- Strategies to provide learning opportunities and to ensure driving competency
- Strategies to limit exposure to dangerous driving situations
- Strategies to involve parents in promoting safe driving behaviors
- Strategies to reduce impaired and distracted driving

Each of these strategies has been considered to some extent in the implementation of graduated driver licensing (GDL) laws. These laws and associated procedures for obtaining a driver's license vary by State of licensure. GDL procedures for obtaining driving privileges on public roads provide teen drivers with opportunities to gain on-road experience and practice driving under low risk conditions. The first phase (learner's permit) allows driving only under the supervision of a fully licensed driver. The second, intermediate phase (provisional license) allows unsupervised driving under certain conditions and with certain restrictions designed to reduce risk. The third stage (full license) allows full driving privileges without any of the GDL restrictions, although even drivers holding the full license may have certain restrictions imposed by the licensing authority (e.g. corrective lenses must be worn by drivers who are unable to pass a visual acuity test without them).

Each of the four categories of strategies for reducing crashes involving teen drivers is discussed below with particular emphasis on the relationship between these strategies and the GDL process. Later in this section, four promising initiatives for further reducing fatal crashes involving teen drivers are discussed.

Strategies to Provide Learning Opportunities and to Ensure Driving Competency

Within the traffic safety community, it is generally acknowledged that traditional driver education courses are not effective for reducing crash rates among young drivers (Hedlund, 2008; NHTSA, 2010; Lonero & Mayhew, 2010). Despite this, courses may be effective for teaching vehicle handling skills and for exposing young drivers to safety information. In fact, some States continue to require a certain number of hours of driving instruction taught by a qualified instructor. A presumption of most GDL laws is that during the learner's permit stage, a parent or guardian will supervise the teen's driving, and this is often formalized by a requirement that the parent certify that some minimum number of hours of on-road supervised practice has taken place (typically 30-50 hours, including10 hours at night). Beyond the traditional classroom plus on-road training provided by driver's education courses, other approaches have included video-based risk perception training, simulator training, and advanced vehicle handling courses conducted on a skid pad. None of these approaches have been widely adopted.

Strategies to Limit Exposure to Dangerous Driving Situations

A key concept underlying GDL systems is to limit the teen driver's exposure to the riskiest driving situations until the teen gains a great deal of on-road driving experience under less risky circumstances. A secondary concept is that delaying independent driving until an older age allows time for the teen to reach a greater level of developmental maturity before driving alone.

State GDL laws vary with respect to minimum age requirements for obtaining a learner's permit (from 14 to 16 years) and for obtaining the intermediate stage license (from 14 years 6 months to 17 years). Limiting exposure by setting the licensing age for independent driving to 17 in New Jersey (the only State that has done this) has resulted in a lower fatal crash rate (Williams, 2008).

GDL restrictions are based on known risk factors and usually limit night driving, transporting underage passengers, and cell phone use. They also require seatbelt use. Some States prohibit police from stopping young drivers solely for violations of night driving restrictions, passenger restrictions, cell phone restrictions, or seatbelt use. This situation is called secondary enforcement. Secondary enforcement laws (for seatbelt use, etc.) generally do not result in compliance rates that are as high as those obtained with primary enforcement laws.

Strategies to Involve Parents in Promoting Safe Driving Behaviors

GDL laws in many States require parents to certify that a certain number of hours of supervised practice has occurred while their teen held a learner's permit. Beyond requiring supervised practice, driver safety programs that involve parent-teen driving agreements such as the Checkpoints program (Simons-Morton & Hartos, 2003) may increase parental limit setting and are viewed as a promising approach (NHTSA, 2010).

Various in-vehicle technologies are now being marketed to parents of teen drivers. These systems are designed to monitor vehicle speed and various maneuvers so that parents may monitor and coach their teen drivers. Some systems record video of the driver and a forward view of the roadway. Generally, evaluations of these systems have been favorable (McGehee et al., 2007; Farmer, Kirley, & McCartt, 2009), although more research is needed to determine how effective they may be for reducing crash rates.

Strategies to Reduce Impaired and Distracted Driving

Raising the minimum drinking age to 21 in all 50 States has been credited with saving more than 27,000 lives between 1975 and 2008 (NHTSA, 2009e). However, enforcement of impaired and distracted driving laws targeted specifically at teens is difficult. Zero tolerance laws in all 50 States are aimed at drivers under the age of 21 who are caught with measurable alcohol in their system (e.g. BAC > .02). According to NHTSA (2010) these laws have not been actively publicized or enforced. A challenge with enforcement is that it is difficult for an officer to determine the age of a driver to know whether the zero-tolerance law applies, and when making the traffic stop, the officer may be required to have evidence of suspicious (intoxicated) behavior prior to testing for alcohol. Persons with low BAC levels may not exhibit obvious behavioral symptoms.

A total of 28 States and the District of Columbia restrict cell phone use by novice teen drivers (IIHS, June 2010a), but enforcement of this restriction also is difficult. NHTSA recommends that teens not be permitted to use portable electronic communication and entertainment devices while driving (NHTSA, 2010).

The recognition that fatigue is a contributing factor in teen driver crashes has prompted some to recommend later morning start times for high schools. Driver assistance technologies such as lane departure warning systems and forward collision warning systems are now available on some vehicle models. Such systems may help drowsy drivers to stay focused on the roadway.

PROMISING INITIATIVES

An excellent discussion of promising strategies for reducing collisions involving young drivers can be found in Volume 19 of the NCHRP Report 500 series (Goodwin, Foss, Sohn, & Mayhew, 2007). The initiatives proposed in this section focus on beginning drivers and do not include initiatives for drivers impaired by alcohol. Alcohol use is an important factor in fatal crashes involving young drivers, especially for those who are 18-20 years old.

Four initiatives are identified here as promising approaches for substantially reducing fatal crashes involving teen drivers. Each initiative may involve several activities. The suggested initiatives are:

- Implement and strengthen GDL laws, and enact primary seatbelt laws.
- Promote effective public information and enforcement of GDL restrictions.
- Encourage a high level of parental supervision of teen driving during the intermediate stage of GDL.
- Promote safer vehicles for teen drivers and ensure they use all available vehicle-based safety features.

Implement and Strengthen Graduated Driver Licensing Laws and Enact Primary Seatbelt Laws

This strategy involves legislative action to implement and build upon existing GDL laws. Since 1996 when Florida implemented the first three-stage graduated licensing system in the United States, GDL laws have been shown to be effective for reducing fatal crashes involving teen drivers although the full potential benefits of these laws may not yet be fully realized. Building on the success of GDL may be the best immediate strategy for reducing teen traffic fatalities (Williams & Mayhew, 2008).

The Insurance Institute for Highway Safety (IIHS) maintains a safety rating system for State driver licensing laws. Under this system 31 States and the District of Columbia had passed laws that receive a "good" rating as of April, 2009 (IIHS, June 2010b; McCartt et al., 2010). The remaining States should be encouraged to strengthen their laws to achieve a "good" rating. The highest ratings are achieved when GDL laws meet the following requirements:

- Minimum age for obtaining a learner's permit = 16 or older.
- Minimum holding period for learner's permit = 6 months or more.
- Required practice hours = 30 or more hours.
- Restriction on night driving during intermediate GDL phase (license that allows unaccompanied driving) = 10 p.m. or earlier.
- Duration of night driving restriction = 12 months or more from minimum licensing age.
- Restriction on underage passengers = zero or one passenger permitted.
- Duration of passenger restriction = 12 months or more from minimum licensing age.

In order to move toward zero deaths, the recommendation here is for States to go beyond the requirements above to conform to a national 16-17-18 GDL age guideline. The proposed guideline represents the minimum age requirements for obtaining a learner's permit, a provisional license, and a full license. For example, seven States already require a 12-month holding period for the learner's permit and an additional three States require a 9-month holding period. A 12-month holding period for the learner's permit ensures that teens have opportunities

for extensive supervised driving experience that includes experience in all seasons. Note that if this requirement is combined with a recommended minimum age of 16 for obtaining a learner's permit, the 12-month holding period will effectively limit licensure (entering the intermediate GDL stage) to teens who are 17 or older. As noted above, a minimum licensure age of 17 is already in place in New Jersey. The initiative proposed here is to restrict licensure to teens 17 or older who have held a learner's permit for at least 6 months. Those teens who obtain a learner's permit on their 16th birthday will have the benefit of a full year (or more) of supervised driving. Passenger restrictions, night restrictions, and cell phone restrictions may vary by State, and would expire at age 18. The 16-17-18 guideline may make enforcement easier for law enforcement officers and may be easier for the general public to understand. All 17-year old licensed drivers would be under GDL restrictions.

It should be noted that results from a recent IIHS study suggest that strengthening GDL restrictions somewhat beyond the values given above may be associated with further reductions in fatal crashes. For example, as compared to allowing two or more young passengers, GDL laws restricting teen drivers to one passenger were associated with a 7 percent reduction in fatal crash rate while GDL passenger restriction allowing no underage passengers was associated with a 21 percent reduction in fatal crash rate (McCartt, et al., 2010). Similar differences were seen for night driving restrictions which varied between States from 8 p.m. to 1 a.m. Restricting driving later than 1 a.m. was associated with a 9 percent reduction in fatal crash rate while restricting driving later than 8 p.m. was associated with a 20 percent reduction in fatal crash rate.

The use of cell phones and other electronic devices is a source of driver distraction and may be especially problematic for novice drivers. According to the Governors Highway Safety Association (June 2010a), 28 States and the District of Columbia have included restrictions on cell phone use within the GDL program, and most of these are primary enforcement laws. According to IIHS (June 2010a), text messaging is banned for all drivers in 29 States and the District of Columbia. In addition, novice drivers are banned from texting in 9 States (Alabama, Delaware, Indiana, Maine, Mississippi, Missouri, Oklahoma, Texas, and West Virginia). Encouraging the remaining States to follow suit by restricting use of cell phones and other potentially distracting devices by teen drivers younger than 18 years old should be a high priority. This issue is discussed further in the section on driver distraction.

Although not specifically targeted at teen drivers, States should be encouraged to enact and enforce primary seatbelt laws as a strategy to prevent traffic fatalities, but especially those involving teen drivers. Annually, more than half of those killed in crashes involving teen drivers were not wearing a seat belt. This issue is discussed further in the section on restraint use.

Promote Enforcement of GDL Restrictions and Community Support of GDL

The safety effectiveness of GDL provisions depends on compliance. Law enforcement departments should be encouraged to enforce GDL restrictions. This may include enforcement activities such as high visibility police checkpoints outside schools or other areas that teens frequent, and checks for GDL compliance during routine traffic stops, especially at night. Other contacts between teens and law enforcement officers should be encouraged to create greater perception of enforcement. This includes increased involvement between law enforcement officers and teens through programs in high schools and other community events.

A particular problem with enforcement of GDL restrictions concerns the difficulty for law enforcement officers (and others) to recognize violators. Violations of both age-based restrictions

and restrictions based on intermediate license holding periods are difficult to recognize unless the teen's driver license is inspected after a traffic stop for some other violation. New Jersey has required young drivers to place an identifying sticker on their vehicle. Despite some public resistance to this requirement (e.g., Wall Street Journal, 2010), it does provide a simple, inexpensive way for law enforcement officers to identify young drivers.

Ensuring compliance with GDL restrictions is not just the responsibility of the police. Social marketing campaigns should be used to increase public knowledge about GDL restrictions. Such campaigns should encourage community responsibility for enforcing GDL. Parents may be the most important and effective enforcers of GDL restrictions, however, many parents find it easier to enforce restrictions on their child's driving when at least some restrictions are mandated by the GDL process. GDL restrictions (along with the threat of traffic citations to the teen for noncompliance and resulting increases in family insurance premiums) provide an "excuse" for many parents to monitor their teen's driving behavior during the intermediate stage of GDL. In addition to parents, social marketing programs should educate and encourage extended family members to take an active role in enforcing GDL restrictions. Other community leaders and authority figures who have close connections with teens such as teachers, coaches, and clergy should be enlisted to provide consistent messages about adherence to GDL restrictions. A community response to teen driving safety is needed (Ruebenson, 2008).

Finally, teens themselves should be encouraged to help enforce GDL restrictions and support their driving peers. The concept of the teen passenger as a "skillful copilot" has been discussed previously (Allen & Brown, 2008). Peer-to-peer programs have shown some promise and some traffic safety experts have suggested this as an area worth pursuing (Williams & Mayhew, 2008). In jurisdictions where teen drivers are allowed to carry one or more underage passenger, a "good passenger" pledge or educational "teen copilot" program may be effective. Such programs would encourage seat belt use by passengers, reducing risk-taking behavior by the teen driver, and reducing driver distraction caused by young passengers. Ideally, the teen copilot would feel empowered to challenge a driver who is not "fit for duty" due to impairment from fatigue, alcohol, or in-vehicle distractions. At a minimum, the potential dangers presented by passengers (especially where the driver and passenger are in the same age group) and strategies for being a helpful passenger should be clearly explained in driver's manuals and included in the knowledge test for driver's license candidates. Teens obtaining a learner's permit may represent a captive (and attentive) audience for messages about safety issues regarding passenger behavior.

Encourage a High Level of Parental Supervision of Teen Driving During the Intermediate Stage of GDL

Despite their inexperience, novice teen drivers have relatively low crash rates during the period when they hold a learner's permit and their driving is actively supervised by a parent present in the vehicle. However, crash risk is highest during teens' first several months of independent driving (Mayhew, Simpson, & Pak, 2003; McCartt et al., 2003). During this period parents often are not physically in the vehicle with their teen driver. However, rather than discontinuing supervision of their teen's driving during this period, parents should be encouraged to closely monitor and actively control their teen's trips. Parents may set limits on when and where their teen is allowed to drive and may closely monitor trips. For example, parents may require their teens to "file a flight plan" by notifying them in advance about each trip (where they are going, routes to be taken, when they expect to return, etc). Parent-teen driving agreements are one effective way to formalize family rules about driving and consequences of not following the

rules. Such tools may help parents to restrict teens driving, for example, from driving late at night (Simons-Morton et al., 2005).

Parents should be encouraged to ride with their teens regularly during the intermediate GDL period to ensure that safe driving habits are being maintained as the teen driver's confidence (perhaps overconfidence) grows. Electronic vehicle monitoring technologies may be an effective tool for parents and teens to use for a limited time during the initial months of independent driving. Consumer-oriented vehicle monitoring technologies are now becoming more widely available. Their capabilities and effectiveness are discussed below.

Recent advances in technology have enabled the development of devices that that measure aspects of vehicle and driver performance, including speed, and provide feedback based on these measurements. Currently available devices typically measure performance using information from some combination of these sources:

- GPS, which determines the vehicle's current location, and can be used to calculate vehicle speed.
- The vehicle's on-board diagnostics port (OBD-II), which outputs data related to vehicle performance and component functionality.
- Device-based accelerometers, which measure longitudinal and lateral forces that provide an indication of the rate of acceleration and deceleration, turning and cornering speed, and vertical bumps (e.g., speed hump or pothole).

Though monitoring devices have not yet found widespread use, early experience among fleet vehicles and novice drivers suggests that they can achieve substantial safety benefits. In Arkansas, an ambulance fleet was instrumented with monitoring devices that gave feedback to drivers when they were speeding, cornering too fast, and performing other unsafe acts. The devices resulted in significant reductions in speeding and other violations, as well as a 20 percent reduction in vehicle maintenance costs (Levick & Swanson, 2005). In Israel, a corporate fleet of cars for employee use were instrumented with devices that monitored speeding, swerving, and hard braking. Drivers received instant feedback in the vehicle when an unsafe event occurred, as well as a monthly report that summarized their performance. Use of the devices led to a 38 percent reduction in crashes per 1,000 miles driven (Musicant, Lotan, & Toledo, 2007).

Though there has been relatively little experience with monitoring devices for novice teen drivers (e.g. Prato, Toledo, Lotan, 2010) early experience is promising. In Iowa, teens' vehicles were instrumented with a device that monitored hard braking and hard turning/cornering maneuvers. The teen received instant feedback in the vehicle when a violation occurred, and a weekly summary report, including video of violations, was sent to the parent. As a result, the rate of violations dropped 72 percent among teens who had relatively high levels of violations before the monitoring device was activated. There were no significant effects among teens who had low levels of violations before the monitoring device was activated (McGehee, Raby, Carney, Lee, & Reyes, 2007). A follow-up study found that the improved performance of the riskier teens was maintained for eight weeks after the feedback period had ended (McGehee, Carney, Raby, Lee, & Reyes, 2007). Another study conducted in the Washington, DC area compared the effects of different methods of feedback on the behavior of novice teen drivers (Farmer, Kirley, & McCartt, 2009). The behaviors monitored in this study were speeding, hard braking and acceleration, and seat belt use. The experimental conditions were: a) instant feedback to driver and immediate parental notification via website, b) instant feedback to driver and parental

notification via website *only if* the driver does not correct their behavior, and c) parental notification via website only (no driver notification). The study found that all conditions led to increased seat belt use and small reductions in hard braking and acceleration. Speeding was significantly reduced only when the driver received instant alerts, the parent received reports that included instances of speeding, and the driver had the opportunity to correct speeding behavior before alerts were sent to the parent.

Promote Safer Vehicles for Teen Drivers and Use of Available Vehicle-Safety Features

The final promising initiative for reducing fatalities in teen driver crashes involves promoting the use of safer vehicles for teens; vehicles that improve the chances of crash avoidance, crash mitigation, and crash survivability. For more information on specific safety features of vehicles, the reader is encouraged to consult the paper on Safer Vehicles from this series.

From the perspective of teen driver safety, it is ironic that new vehicle safety features are not adopted early by drivers with the highest crash risk. New safety features tend to be introduced as options on high end vehicles, which tend to be too expensive for teens to purchase. Instead, these vehicles generally are purchased by middle-age drivers (the age group with the lowest crash rate) for their own use. In cases where these middle aged adults have teenage children, older used vehicles may be passed down to their teen driver. In fact, a recent study found that three quarters of the vehicles designated for use by teen drivers were already owned by the family (IIHS, 2007). This means that teen drivers tend to have vehicles that are at least one generation of safety technology out of date. The situation is worse for families with limited financial resources. Only after safety technologies achieve high penetration in the used vehicle market do teens get access to equipped vehicles.

Beyond the availability of specific safety features, families should consider the types of vehicles that are most appropriate for teen drivers. For instance, many families believe that SUVs are a safe choice for teen drivers because of their size, but the more difficult handling, poorer visibility, and propensity to roll over can actually increase the likelihood of a crash (Stark, 2004).

The initiative proposed here is to promote safer vehicles for teen drivers. This would be a two-pronged approach:

- The federal government should promote development of safer vehicles with features for novice drivers and should encourage vehicle manufacturers to include emerging safety features in models marketed to young drivers and families that share a vehicle with a young driver. Some manufacturers have already moved in this direction. The Ford My Key system is one example of this approach.
- Further efforts should be made to educate parents and teens about appropriate criteria for choosing safe vehicles for young drivers.

Advanced safety features such as lane departure warning systems and drowsy driver detection systems may be particularly beneficial for teen drivers, who as a group may be particularly sleep deprived (Dahl, 2008). Forward collision warning systems and automatic braking systems have the potential to reduce fatalities among distracted teen drivers.

IMPACT, COSTS, AND FUNDING

The table below summarizes the suggested initiatives for young drivers. The percentage reductions in fatalities are based on fatalities in crashes involving young drivers (ages 15-20). There were a total of 6428 of these fatalities in 2008 (NHTSA, 2009e).

Table 4. Initiatives to improve young driver safety.

STRATEGY	AIMED AT	POTENTIAL FATALITY REDUCTION	WHO BEARS COST	COSTS (IMPLEMENT/ MAINTAIN)	OBSTACLES TO IMPLEMENTATION
Implement and strengthen GDL laws, and enact primary seatbelt laws. (16-17-18 licensing age guideline, 0 or 1 young passenger, night restriction after 9 or 10 p.m. - all adopted by all States)	Fatal crashes involving drivers less than 18 years old	25% reduction	Public	Relatively low costs to implement	Political acceptance of stricter laws
Promote effective public information and enforcement of GDL restrictions	Fatal crashes involving drivers less than 18 years old	5-10% reduction	Program implementers (public or private), Law enforcement agencies, taxpayers	High costs of sustained vigorous law enforcement. Lower costs for public involvement. Moderate costs for social marketing.	Broader societal attitudes about personal freedom, government and law enforcement control
Encourage a high level of parental supervision of teen driving during the intermediate stage of GDL	Fatal crashes involving drivers less than 18 years old	5% reduction	Parents, Program implementers (public or private)	Program costs, technology costs for in-vehicle monitoring (est. $500 plus $50 monthly data charges per vehicle to maintain)	Parental willingness, teen acceptance
Promote safer vehicles for teen drivers and ensure use all available vehicle-based safety features	All crashes involving young drivers, particularly those related to young driver fatigue and driver distraction	5% reduction	Vehicle manufacturers, consumers, parents	R&D costs to develop and implement safety technology; costs of social marketing	Parental and teen acceptance; OEM perceptions of market demand

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