UNITED STATES GOVERNMENT STATUS REPORT

Joseph N. Kanianthra
National Highway Traffic Safety Administration
United States

State of Motor Vehicle Crashes

In 2005, 43,443 fatalities occurred in the U.S. as a result of motor vehicle crashes. This is contrasted with the 54,589 people who were killed in traffic crashes in 1972 and 39,250 in 1992, the highest and lowest in the past 35 years.

The fatality rate per 100 million VMT in 2005 was 1.45. This is contrasted to 5.5 fatalities per 100 million VMT in 1966, the highest in the past 35 years. Similarly, the fatality rate on a person basis was 14.66 fatalities per 100,000 population in 2005. This is compared to 26.42 in 1969. In 2004, the fatality rate per 100,000 population (14.35) was the lowest in the past 35 years.

Motorcycle rider fatalities, after a major decrease in the 1980s and early 1990s, have increased steadily since a historic low in 1997. In 2005, motorcycle rider fatalities numbered 4,553, an increase of over 2,437 fatalities from the 1997 level.

The total number of police-reported crashes in the U.S. in 2005 was estimated by the National Automotive Sampling System (NASS) General Estimates System (GES) to be 6.2 million. These police reported crashes resulted in 2.7 million persons being injured. In recent years, the estimated number of injuries has decreased, as has the injury rate, based on VMT. In 2005, the injury rate reached 90 injuries per 100 million VMT.

In 2005, safety belt use reached a usage rate of about 81 percent for outboard seated occupants during daytime hours.

State of Motor Vehicle Safety

Over the past several decades, the fatality rate per VMT has been steadily decreasing. The safety improvements made are due in part to the collective efforts of the operating agencies of the Department (The National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), the Federal Highway Administration (FHWA), Federal Transit Administration (FTA) and the Federal Railroad Administration (FRA))the States, automobile manufacturers, and other organizations.

NHTSA's engineering efforts combined with its educational and enforcement programs that ensure proper compliance with the U.S. regulations have been major contributors to this significant achievement in safety. Figure 1 shows the number of fatalities and the fatality rate for the period 1966 to 2005.

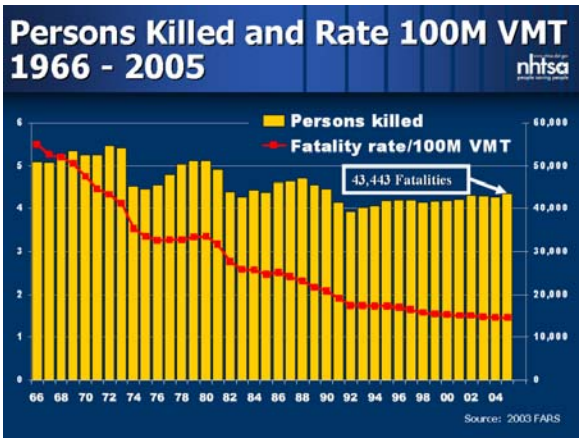

Figure 1. Fatalities and Fatality Rate vs Time

As can be seen from Figure 1, the fatality rate is leveling off and, in light of the fact that the vehicle miles traveled is steadily increasing, any significant reduction in total fatalities can occur only if new and bold initiatives are explored. Further, the fatality trends in the United States show that for the last several years, the total fatalities have been fluctuating between 42,000 and 43,000. If no improvements are made, and the current rate of VMT growth continues, the number of fatalities could increase to 54,000 in 2016 (see Figure 2).

Figure 2. Fatality Rate Goal

Just to maintain today's level of fatalities, the average fatality rate must be 1.2. These projections point out the need to start taking a very aggressive and pro active role in trying to meet such a target.

Another factor affecting the fatality rate is the changing demographics of the population at large. Shown in Figure 3 is the projected shift in the population for age groups 65 and older and for 85 and older. As can be seen, there will be substantial increases in their numbers. This increase plays a role in the fatality rate as persons who are in these age groups are more susceptible to injury for a given crash.

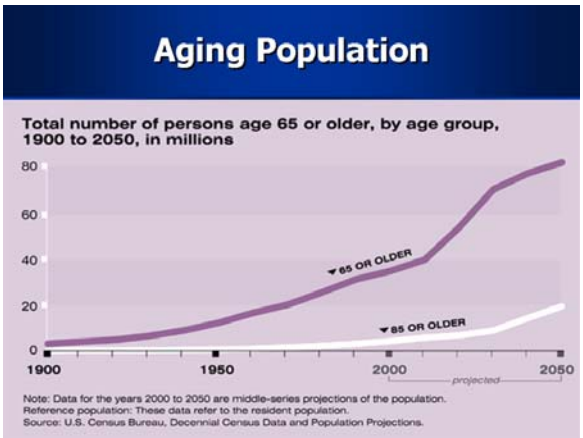

Figure 3. Aging Population

Another factor affecting the fatality rate is the increase in motorcycle fatalities. While having declined for a long time, the recent trend is a substantial increase in fatalities. Shown in Figure 4 are a breakdown of fatalities by passenger vehicle occupants; motorcycle riders; and truck, bus and non-motorists.

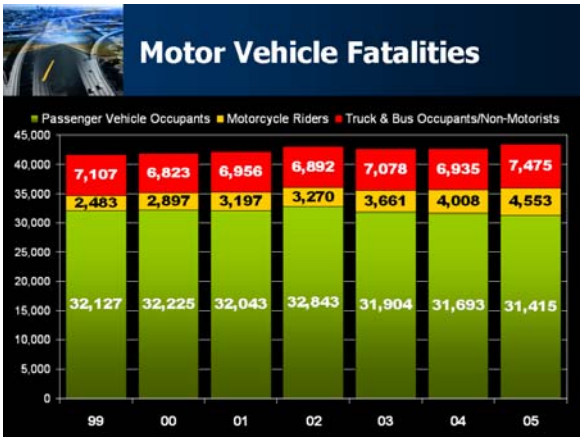

Figure 4. Breakdown of Motor Vehicle Fatalities

New thinking must be given to what can be done that will reverse these trends. While NHTSA should introduce programs to achieve minimum safety performance, only new additional initiatives would result in substantial safety gains.

Evolving Research Strategy

From the beginning of the twenty-first century, the state-of-the-art in motor vehicle safety has been going through significant changes. In-vehicle advanced technologies such as electronic stability control that apply corrective measures to augment control of the vehicle by the driver in critical situations are being deployed. Advanced technologies available in many of today's vehicles can warn the driver of imminent crash situations. Also, new technologies such as communication devices, navigation aides and other devices that may help drivers also have the potential to negatively impact safety because of the attention demands placed on the driver that detract him/her from the primary task of driving.

Occupant protection is being improved through the development of advanced restraint systems that can adjust their performance taking into consideration occupant and crash characteristics. Event data recorders are in vehicles that will allow the vehicle safety community to better understand crash characteristics and to properly evaluate factors leading up to a crash.

The Agency is beginning to shift its research strategy to take advantage of these emerging technologies. The use of these advanced technologies can help with new and innovative solutions to both current and emerging safety problems. They can supplement the more traditional approaches related to crash avoidance, reduction of crash severity, occupant protection, post-crash safety, and structural integrity of motor vehicles.

The existing vehicle related activities in the Agency may have to be expanded in the future to achieve the safety targets mentioned previously. Even with the anticipated benefits of the Electronic Stability Control technology's substantial safety benefits, the Agency will be short of that target. It appears that the continued hope for significant safety benefits lies within pre-emerging and emerging vehicle technological advancements. However, it should be stressed that, while significant safety benefits are achievable that could meet these safety goals in a

shorter period of time and help close the gap, it is not possible at this point to implement all these technologies and achieve sufficient penetration of the fleet in the near future to completely obtain the required safety benefits. But the faster these type of programs are initiated, the quicker these safety targets can be reached.

A number of safety problems may be amenable to technological solutions. For example, the absolute number of total crashes has remained about the same over the past several years. The absolute number of drivers in fatal crashes with a high Blood Alcohol Concentration has remained high over several years. The percentage of passenger car and light truck occupants killed not wearing safety belts is approximately 52 percent. Motorcycle riders killed has increased from 2,483 in 1999 to 4,553 in 2005. Pedestrian fatalities have stayed the same for several years. The majority of fatal crashes occur on un-divided roadways. Single vehicle crashes represent 57 percent of total fatal crashes and 70 percent of them occur off the roadway/on the shoulder/median, whereas 95 percent of multi-vehicle fatal crashes occur on the roadway. Determining if advanced technologies be brought to bear in addressing these safety problems in addition to other approaches is a question that is currently receiving the agency's attention.

An important role that is emerging in the NHTSA's Office of Vehicle Safety Research's (VSR's) mission is that of being a pro-active leader in enhancing motor vehicle safety. The state-of-the-art in motor vehicle safety is going through significant changes. In-vehicle advanced technologies such as electronic stability control, collision avoidance warning systems, and advanced air bags are being deployed. Even though some of these technologies are being deployed voluntarily, deployment of those that are truly safety beneficial needs to be accelerated through rulemaking actions, consumer information/education programs, and other methods. VSR is dedicated to achieving a better understanding of the role of these technologies in improving all aspects of safety, their potential safety benefits and to understand the impact of any unintended consequences. VSR is also dedicated to exploring new technological concepts and the means to facilitate their deployment in order to enhance motor vehicle safety. It should be stressed that the discussions related to advanced technologies are meant to cover the complete spectrum of driving represented by a crash timeline that include crash prevention, crash severity reduction, crash protection, and post-crash events.

The emerging technologies have a high potential of helping to meet the safety targets of NHTSA. However, there is a need for accelerating the introduction of those technologies that are truly beneficial for safety. In its traditional role of promulgating safety regulations, NHTSA does not generally mandate technologies. Other methods such as development of test and evaluation procedures for technology based full system countermeasure evaluations must be pursued in crash prevention, crash severity reduction, crash protection and post-crash safety. These results can support rulemaking, consumer information programs, and ratings and other programs. Thus, NHTSA research needs to be engaged in ensuring that these new technologies are properly deployed to maximize their safety capability.

Ten objectives being followed in NHTSA's Office of Vehicle Safety Research are presented below. The earlier conceptual objectives are meant to relate to all vehicle types and to cover both crash avoidance and crashworthiness research areas. They also introduce the integrated safety concept that relates to all areas along the crash time line mentioned above. The programmatic objectives which are presented toward the end are meant to highlight some specific issues/opportunities.

Objective 1. Identifying opportunities for safety enhancement. Previous NHTSA research activities have been based on the well known Haddon matrix (see Figure 5) developed by Dr. William Haddon, Jr., the first Administrator of NHTSA's predecessor agency, the National Highway Safety Bureau. The well known, nine-cell matrix has been the guiding beacon for the Agency's activities in research, regulations, driver behavioral programs, highway safety standards, and emergency medical services. Clearly demarcated distinctions that existed between the human, the vehicle and the environment and their roles in pre-crash, crash and post-crash events have been apparent for many years, and this has facilitated the development of programs to address the safety problems related to each of these cells in the Haddon matrix.

As vehicle technologies evolve, these clear distinctions are fast disappearing, and there is considerable overlap between the human and the vehicle as well as the vehicle and the environment across the board from the pre-crash to post-crash events. This shift demands a change in the approach that safety experts must adopt to address the emerging safety issues in the future.

Figure 5. Haddon Matrix

Consider the events that precede a crash and those that occur during and after the crash. Driving can be considered to be a benign and uneventful activity most of the time as long as the road conditions are conducive and the traffic environment is suitable. In the same vein, the vehicle needs to be in good condition and the driver must be physically able to drive, taking advantage of all the safety devices that are available in the vehicle at the vehicle user's disposal. These events can be placed along a time line as mentioned before and shown in Figure 6. The critical time periods from a safety perspective are the few critical seconds before time zero, the few milliseconds during the crash, and the few minutes after the crash.

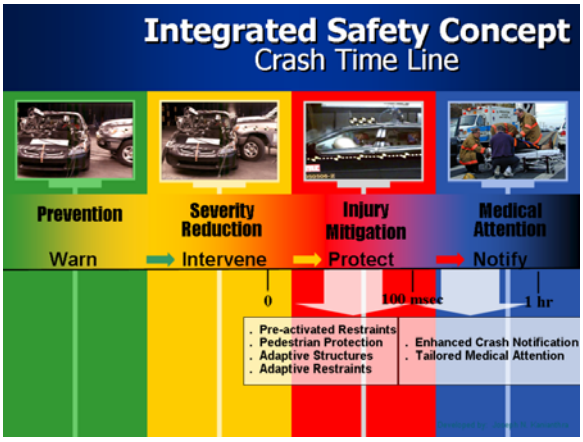

Figure 6. Crash Time Line

Vehicle technologies can be incorporated into every phase of these events along the time line even far before time zero, where time zero is defined as the time at which a crash occur, if a manufacturer so desires. Technologies are becoming available at a fast pace. There is also added pressure from inventors of technologies to load vehicles with features that could possibly attract more customers. Many of the features are attractive and consumers do demand them once exposed to their capabilities. However, while the Agency should positively reinforce these efforts, the Agency also must emphasize the importance of the designs in addressing safety critical parts of the pre-crash, crash and post-crash events, in addition to being attractive features.

There is no question that technologies are bringing new opportunities for enhancing safety in vehicles that never existed before. For example, many new technologies are already on the road or are on the verge of introduction in vehicles. These include products that are extensions of the antilock brake systems such as electronic stability and traction controls, and adaptive cruise controls, road departure warning systems, night vision systems, advanced restraint and occupant protection systems, and other such systems. Many of these technologies are expected to improve safety. However, many have not undergone the evaluation of their effectiveness in real-world scenarios of driving. Such evaluations require a considerable amount of research, analyses and testing, and expense.

In estimating the benefits, an analysis of the safety problems and target populations at each stage of the crash event is important (see Figure 7).

Figure 7. Safety Cycle

An important element in this process is the development of suitable test procedures that are objective and are related to real-world problems. Results from the use of these test procedures will be a key source of information for estimating the

anticipated benefits in addressing specific safety problems. These steps are difficult to carry out by the Government alone because suppliers and manufacturers are the experts in technologies, and not the Government.

Introduction of technologies through regulations would only be possible after developing suitable evaluation protocols and after estimating the likely benefits that may result in solving real-world safety problems. This is especially important because the Government does not generally mandate technologies and they need to be based on total systems' safety performance and requirements. An additional approach is to find other means such as dissemination of consumer information and using market forces as drivers for deployments of safety technologies by automobile manufacturers.

The rapid introduction of technologies to the market, while representing a positive direction in addressing safety concerns, has raised questions as to the level of safety benefits and practicability of many of these technological concepts. The performance specifications are not standardized and the same concepts may have widely varying performance and resulting safety benefits. The key is to determine how well the technologies that are under consideration address the safety problems, how well they meet the demand of various situations along the crash time line and to what extent they really help in preventing crashes or in reducing their severities, and protecting the occupants when crashes are unavoidable.

Objective 2. Develop an Understanding of the performance of advanced technologies: Future Opportunities for Total Safety. In order to keep abreast of technologies that are available and to understand their suitability for safety applications, research staff are in constant contact with Tier I suppliers in the United States and abroad and the automobile manufacturers to seek information. The information obtained are being utilized in planning research programs for both light vehicles and heavy vehicles, and implementing research projects with the objective of determining feasibility of countermeasure system development for solving safety problems.

The evaluation of the effectiveness of technologies would include a comparison of the different technologies aimed at mitigating the same safety problems such as rollover or rear-end collision, for example. This comparative analysis will be able to examine how the different performance characteristics affect safety under different real-world situations. Additionally, integration of multiple technologies and data fusion would be an important element in their research and evaluation.

The objective of the above work will be directed at being pro-active in developing new technological concepts that can enhance safety through:

- Performance improvement of vehicle sub-systems such as safety belts, seats, child seats, structures, glazing, etc.
- Performance improvements in crash prevention, driving performance, driving assistance, and crash severity reduction, etc.
- Performance improvements in crashworthiness related to compatibility, air bag performance, and other crash protection and injury mitigation systems, etc.
- Performance improvements related to pedestrian protection, two-wheeled motorized vehicle safety, impaired and drowsy driving, etc.

Under this objective, research will be undertaken that cuts across the traditional areas of crash prevention, crash severity reduction, occupant crash protection and post crash safety. Those new technologies that have the potential to mitigate safety problems in more than one phase of the timeline that represents the crash event will be considered as a research priority. Thus, a technology that includes the use of forward looking radar can have effectiveness at avoiding a crash, mitigating the severity of a crash, and assisting in the optimal deployment of the air bag and other restraint systems

Objective 3. Address driver vehicle safety issues related to advanced technologies. The human factors issues are of paramount importance as many different technologies are introduced into vehicles. This is particularly of importance when they are employed for improving driving performance or when they are used as driver assistance products. The research involved will include studies of how such technologies affect the ability of drivers to process information, improve driving capacity or improve driver alertness. Ability for drivers to cope with the information that is continuously being provided and work load issues will be investigated. When technologies intervene in the driving even minimally such as in limited control technologies, for customer acceptance, it may be important that such intervention at least in some cases is done in an unobtrusive manner so that it does not appear to deviate from the normal driving habits of people.

Objective 4. Develop Performance and Objective Tests to establish the effectiveness of advanced technologies. An integral part of the research activities will be focused on objective test tools development, performance criteria, test devices and test procedures development including computer simulation tools and methods. These tests and procedures will enable NHTSA and other organizations to evaluate the potential safety benefits of various systems and to assess the relative performance of systems that use different technologies with the objective of solving the same problem. These tests and procedures will support the Agency's rulemaking, consumer ratings, consumer information and other approaches to facilitate introduction of advanced technologies.

Objective 5. Retaining Leadership in Human Injury Research and Advancement of Injury Criteria, Test Devices and Procedures. NHTSA has provided for many years the necessary data for understanding crash injuries through its own research on human injuries. Such data have provided the basis for establishing human injury tolerance levels through scientific analysis of the data. The Agency has also conducted objective biofidelity evaluations of anthropomorphic test devices and made recommendations on the suitability of such devices for its own use and to other public and private entities. As a safety agency responsible for ensuring safety of vehicle occupants, it is important that NHTSA retain this leadership role, and through cooperative efforts with other organizations, in an attempt to avoid myriads of test tools, test devices and injury metrics appearing on the safety scene.

Objective 6. Heavy Vehicle Safety Enhancement. Just as in light vehicles, heavy vehicle safety improvement through the use of advanced technologies is equally important. Available technologies for each phase of the crash event will be actively pursued. In-vehicle technologies intended to promote safety will be pursued, their safety benefits assessed and their unintended consequences, if any, determined. In consultation with the Federal Motor Carrier Safety Administration, regulatory and consumer information related research will be pursued.

This subject is covered in the Agency's rulemaking and supporting research priorities plan under the section titled: "Make Large Trucks Safe", and the reader is directed to that discussion. The two areas discussed include improvements in braking and reducing large truck tire failures.

Heavy truck rollover is another area of concern that accounts for a high percentage of truck driver fatalities. As part of the Intelligent Vehicle Initiative, technologies have been tested that will assist the driver in potential rollover situations.

Objective 7. Safety Issues related to Alternatively Fueled Vehicles. Alternative fuel research by vehicle manufacturers is of growing importance. Several fuels are under consideration as substitutes for petroleum fuels. The research efforts for this program are discussed in the Agency's rulemaking and supporting research priorities plan under the section titled: "Hydrogen, Fuel Cell and Alternative Fuel Vehicle Safety Research". As indicated in the document: "NHTSA's program for hydrogen, fuel cell, and alternative fuel vehicles is focused on establishing safe performance requirements for hydrogen-powered internal combustion engine (ICE) and fuel cell vehicles." That discussion is not repeated here and the reader is directed to the Agency's rulemaking and supporting research priorities plan.

Objective 8. Motorcycle Safety. As previously mentioned, in 2005, motorcycle crashes accounted for 4,553 rider fatalities. This is an increase of approximately 60 percent over the last five years. Using the base year of 1997 (2,116 fatalities), which the Agency generally uses for motorcycle crashes, the increase is 115 percent. However, it is noted that there is also a significant increase in motorcycle registration during that same period. Alcohol use and speeding are cited as major contributing factors in these crashes. Helmet use in fatal crashes is approximately 50 percent.

NHTSA's recent efforts related to motorcycle safety foster motorcycle rider education and licensing, reducing the number of impaired motorcyclists, increasing motorist awareness of motorcycles, and increasing helmet use. Previous efforts related to vehicle countermeasures examined helmet improvements, braking and other crash avoidance enhancements, and crashworthiness concepts.

Objective 9. Pedestrian Safety. Nearly 4800 lives are lost each year due to pedestrian crashes. NHTSA is addressing the pedestrian safety problem through education, enforcement, and outreach. Goals include reducing the number of impaired pedestrian injuries and fatalities, improving the safety of elderly pedestrians and reaching diverse communities.

The primary vehicle oriented countermeasure research is centered on improving the frontal

structure of passenger cars to mitigate head and lower extremity injuries. This involves examining the stiffness and geometric characteristics of the bumper and hood areas of the vehicle. It has been shown in past research that vehicle parameters such as more clearance to under the hood engine components, streamlined front ends, energy absorbent bumpers, and laminated windshields result in less severe injuries to pedestrians when they are struck.

Advanced technology systems utilizing radar, vision concepts and other types of sensors have been examined to identify pedestrians at intersections and to potentially provide warnings to drivers.

Objective 10. Impaired Driving, Drowsy and Distracted Driving. NHTSA's programs to combat impaired driving and drowsy and distracted driving primarily employ education and enforcement programs. However, many new technologies are appearing on the market that could detect and assist drivers in overcoming the problem.

There are several vehicle suppliers working on developing and implementing concepts to detect drowsy drivers and to then issue warnings to the driver. Many technologies aimed at detecting drowsy drivers are available today. VSR is addressing the potential of in-vehicle safety and non-safety technologies to distract the driver as part of workload management studies.

Approaches to prevent impaired driving and technologies to detect impairment when the alcohol level in the blood stream of drivers is above a certain level, are being pursued through research. Reliable and acceptable detection can provide warning and assistance systems that provide feedback to the driver when alcohol is detected.

Status of Current NHTSA Research Programs

Crashworthiness research

Incompatibility between Passenger Cars and Light Trucks

For decades, the light vehicle category consisted primarily of automobiles. The growing popularity over the past 10 years of light trucks, vans, and utility vehicles (LTVs), all weighing 10,000 pounds gross vehicle weight rating (GVWR) or less, has changed the marketplace as well as the safety picture. LTV sales have soared to almost eight million units sold in 2002 – 49 percent of all new passenger vehicle sales. In 2003, the number of registered LTVs in the United States exceeded 85 million units or approximately 37 percent of registered motor vehicles in the U.S. The majority of LTVs are used as private passenger vehicles and the number of miles logged in them increased 26 percent between 1995 and 2000, and 70 percent between 1990 and 2000. Beyond the growth in sheer numbers of vehicles, LTVs also have increased in size, the curb weight gaining on average about 300 pounds from 2000 to 2004, whereas passenger cars gained approximately 110 pounds during the same period.

NHTSA is continuing research to identify vehicle characteristics that affect compatibility and evaluate their effects in real world crash performance. Several compatibility performance metrics have been developed and are being evaluated against real world crash experience and staged vehicle crash testing. In addition, evaluation of compatibility performance measures using sophisticated computer models is being done to assess the impact of vehicle changes on safety performance under controlled conditions. In addition to NHTSA's initiatives, vehicle manufacturers have committed to a set of voluntary standards for enhanced vehicle-to-vehicle crash compatibility. NHTSA is closely monitoring these voluntary efforts and research developments from industry participants.

Crashworthiness Rollover – Ejection Mitigation

The crashworthiness rollover research program can be separated into two main topics, ejection mitigation and protection for non-ejected occupants. The ejection mitigation program is aimed at occupant containment countermeasures, developing performance requirements, test procedures for evaluating these countermeasures, and developing procedures to evaluate rollover sensor performance. The research program for the protection of non-ejected occupants includes roof crush test method development and rollover restraint performance. Ejection is a major cause of death and injury in light-vehicle rollover crashes. Almost two thirds of all ejection related fatalities occur during rollover crashes. NHTSA is pursuing a phased approach to reducing occupant ejection in rollover crashes. The recently proposed side impact pole test would provide improved head protection for occupants, and likely result in greater use of side curtain air bags. The ability of window curtains in preventing ejections remains to be proven. Depending on their characteristics and performance, as well as other design features such as tethers, window curtains could be designed to prevent ejections. However, much work remains to be done in this area. The next phase is to establish performance requirements for

rollover sensors. The agency collected considerable information (from manufacturers and suppliers) in its effort to develop a research plan for rollover sensor performance requirements.

Side Impact Research

NHTSA's FMVSS No. 214 upgrade proposal would require auto manufacturers to provide head protection in side crashes and to enhance thorax and pelvis protection for a wider range of vehicle occupants. The proposed upgrade augments the current side-impact standard by requiring an additional performance test involving a 20-mph (32 kph) vehicle side crash into a rigid pole at an approach angle of 75 degrees. The Agency is moving toward incorporating the more precise biomechanical knowledge provided by second generation side impact dummies. The upgrade proposes the use of two dummy sizes representing a 5th percentile adult female and a 50th percentile male dummy for both the proposed oblique pole test and the current FMVSS No. 214 barrier-to-vehicle test. In order to develop this proposal, the Agency has undertaken research in biofidelity assessment of dummies. Additionally, a number of crash tests were also undertaken to generate the necessary data for benefits assessment.

Integrated Safety

Integrated safety systems utilize data from crash avoidance systems to improve vehicle crashworthiness. An example of this is the use of radar-based crash threat systems intended to provide adaptive cruise control and/or driver warnings being used to trigger advanced restraints if a crash becomes inevitable. Such an integrated system could improve the current level of 50 percent effectiveness of restraints in fatal frontal crashes using crash pre-view information. Further, if also equipped with an occupant sensing system, advanced adaptive restraints could offer new functionality that would adapt in real-time to the severity of a crash and the particular needs of an occupant in that crash. Similarly, if braking systems are linked to radar systems, then the vehicle could exert full braking at the last second to reduce crash energy. NHTSA is implementing a cooperative agreement with the automotive industry to develop performance criteria, objective tests, and preliminary benefits estimates for both crash imminent braking and advanced front seat restraints. Also of interest are integrated safety systems for rear seat restraints, and research in this area will be addressed next year.

Hydrogen, Fuel Cell and Alternative Fuel Vehicle Safety Research

NHTSA's program for hydrogen, fuel cell, and alternative fuel vehicles is focused on establishing safe performance requirements for hydrogen-powered internal combustion engine (ICE) and fuel cell vehicles. NHTSA's safety initiative will complement the efforts by the U.S. Department of Energy and the U.S. Council for Automotive Research (U.S.CAR). NHTSA's approach is to develop foundational research information that will be necessary to determine future requirements.

Event Data Recorders

NHTSA has been conducting research and collecting information related to Event Data Recorders (EDR) for several years. Circa 2000, NHTSA sponsored two working groups, one on light duty vehicles and one focused on heavy vehicles. Both working groups published findings, available on NHTSA's web site at www.nhtsa.dot.gov. Since 2000, NHTSA has concentrated on the collection of EDR data via its National Automotive Sampling System Crashworthiness Data System (NASS-CDS) and Special Crash Investigation (SCI) programs. Several thousand EDRs have been read as part of these routine crash investigations. Based on the information gathered, the agency initiated a rulemaking action on EDR (see rulemaking section near end of report).

Biomechanics

NHTSA's Human Injury Research Division and Applied Biomechanics Division have developed a Biomechanics Research Plan to build upon the rich history of impact biomechanics research supported and carried out by NHTSA over the past 30 years. The plan prioritizes the research activities based on the needs for rulemaking. The safety needs are established on the basis of frequency, cost, and fatal outcome of crash injuries. Based on the analyses, the plan has developed a set of projects that address the rulemaking and safety needs and can be grouped into the following areas: Injury Mechanisms Research, Anthropometric Test Device Research and Evaluation and Vulnerable Occupant Injury Research. A brief discussion of each is described below.

Injury Mechanisms Research

The field data analysis indicates that occupants in car crashes continue to suffer serious injuries to the head, chest, and lower extremities. Research into head and brain injury is underway to understand better the mechanisms of these injuries through experimental

and analytical methods. The SIMon (**S**imulated **I**njury **Mon**itor) model for the brain (Figure 8) has been enhanced to include more detail of brain structure and incorporates a more refined mesh and material properties.

Chest and thoracic organ injury research includes understanding the properties of the rib structure and the underlying organs. A repeatable test is being developed to evaluate human surrogate and crash dummy chest and shoulder response in three dimensions. University supported research is looking at impact response of underlying tissue that may be incorporated into future injury criteria. Work also continues on finalizing the lower extremity response to impact that will develop injury criteria for knee, thigh, and hip regions.

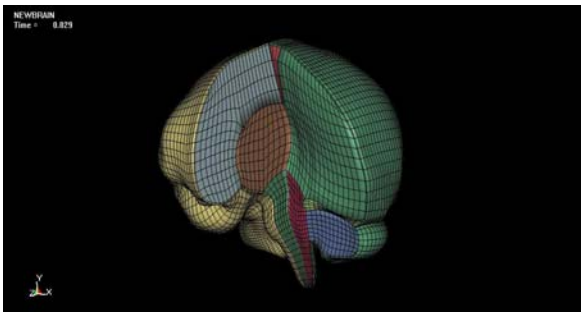

Figure 8. Enhanced SIMon Finite Element brain model

Anthropomorphic Test Device Research

At the 2005 ESV, NHTSA announced the release of the THOR-NT, advanced 50th percentile male frontal impact dummy. Since then, THOR-NT has undergone significant testing of various types and evaluation by NHTSA, industry, and academia. The data have been catalogued and are available to researchers to assess the biofidelity and overall response of THOR. Future enhancements are anticipated through worldwide partnerships that will help bring THOR into its design intent of evaluating future restraint systems that are being developed for automobiles.

NHTSA has been heavily involved in evaluation of side impact dummies (ESII-re, SIDIIs, Q3S and WorldSID) and child dummies (Hybrid III 6yr and 10 yr.), and rear impact dummies (Hybrid III and BioRID). The assessment follows the process that leads to federalization of these dummies for use in regulation. The Human Injury and Applied Biomechanics Divisions have developed injury criteria and calibration and certification procedures for these dummies and continue to work with industry and dummy manufacturers to complete these projects. Future enhancements to these dummies include advanced methods to measure head and torso rotation (rear impact dummies) and to measure chest deflection at multiple locations by non-mechanical means (for frontal and side impact dummies). These enhancements will lead to relevant injury criteria that address the injuries seen in the crash field data.

Vulnerable Occupant Injury Research

Vulnerable occupants include children, elderly occupants, and pregnant occupants. Dedicated research efforts are underway to understand the issues and determine research efforts required. For elderly occupants, analysis will be performed on NASS-CDS and CIREN data on elderly injury to compare injury trends in the two databases. Subsequent CIREN data analysis regarding injury causation and mechanisms for older case occupants compared to younger case occupants will be done. Research on elderly injury tolerance through the testing of human surrogates and different size dummy tests with current and advanced restraint systems is underway and will help to determine the need for age-based injury criteria.

For children, NHTSA is coordinating a multi-center research effort to better understand child head and neck injury mechanisms and associated, non-scaled injury criteria, shoulder and thoracic injury responses and abdominal injury tolerance and criteria. This effort may lead to child dummy improvements and the creation of a human child computer model for further injury assessment in crash reconstructions and other tests.

Crash Injury Research Engineering Network (CIREN) Developments

CIREN is composed of 8 level one-trauma hospitals. Spanning the United States and funded by NHTSA, Honda R&D Co., Ltd., and Toyota Motor North America, Inc. CIREN continues to produce “real-world” research findings on crashes, injuries, treatments, and outcomes. CIREN medical researchers, working with engineers at NHTSA and in the automotive industry and research universities, have produced more than 150 scientific papers and presentations analyzing the basic causes of more than 3,000 cases of serious crash injuries. CIREN is exploring new ways to enhance NHTSA’s and the public’s understanding of injury causation in crashes and refining the capability to define injury criteria. Two of these are the Biomechanics Tab (Bio Tab) and Digital Imaging and Communications in Medicine (DICOM). The Bio Tab is a unique

CIREN application that provides a means to completely and accurately analyze and document the physical causes of injury based on data obtained from detailed medical records and imaging, in-depth crash investigations, and findings from the medical and biomechanical literature. In 2006, the CIREN centers began collecting DICOM images that are the base radiographic digital images captured during CT or MRI scans that may shed further light into the understanding of injury causation and mechanisms.

Heavy Vehicle Research

NHTSA's heavy vehicle research program is directed toward improving the collision avoidance capabilities of these vehicles. A wide range of issues are currently being researched including: brake system performance improvements, enhanced heavy vehicle stability, eliminating blind spots around large combination vehicles through video/camera imaging technology, and evaluating ITS technologies such as electronically controlled braking (brake-by-wire), rear collision warning, and drowsy driver monitoring systems.

The agency research has shown that major improvements in braking performance for truck tractors can be achieved by using disc brakes, larger drum brakes, or hybrid combinations of disc and drum. Stopping distance improvements of up to 30 percent or more have been demonstrated.

Electronic Stability Control (ESC) systems can reduce loss of control crashes involving heavy vehicles, which often result in rollover or jackknifing. Specific studies underway include testing at NHTSA's VRTC facility in Ohio, an ESC effectiveness study utilizing hardware-in-the loop simulation, and a National Advanced Driving Simulator (NADS) study involving over 100 commercial drivers.

Blind spots around large combination vehicles contribute to lane change/merge crashes which are a significant portion of crashes involving tractor semi-trailer vehicles. As a result, performance specifications are being developed for camera/video imaging systems (C/VIS). Based on these specifications, work has been initiated to develop and evaluate a system to provide 360 degree all-weather vision for the driver. This program will result in information on the potential safety benefits, driver acceptance, and overall system performance for C/VIS technology.

ITS technology evaluations are also a part of the heavy vehicle program. Three field operational tests (FOTs), assessing an array of heavy vehicle crash avoidance systems, have been performed. An FOT evaluating rear end collision warning technology has been completed, resulting in safety benefits (crash reduction) estimates, user acceptance data, and system performance information.

Intelligent Technologies Research

Advanced Collision Avoidance Technologies

In response to increasing public concern about automobile safety and advances in technology, many manufacturers and their suppliers are developing and incorporating advanced safety into their vehicles that help drivers avoid crashes. These systems are intended to prevent or reduce the severity for many of the most significant crash types including rear-end, lane change, driver impairment, rollover, and road departure.

This program will develop and implement a framework to develop a Safety Value for vehicles that are equipped with emerging advanced safety technologies. In order to accomplish this we will:

- Define pre-crash scenarios and critical events based on existing accident data.
- Develop objective tests that measure the effectiveness of the feature in addressing specific crash scenarios and critical events.
- Compute the Safety Value for vehicles equipped with these advanced safety systems.
- Develop estimates of potential safety benefits when such technologies are deployed fleet-wide.

In 2007, NHTSA started cooperative agreements with four automobile manufacturers focused on technologies that address Pre-collision Mitigation, Back-over Prevention, lane departure prevention and driver monitoring. These programs will result in objective information that can help consumers identify the most effective safety technologies.

Integrated Vehicle-Based Safety Systems (IVBSS) Initiative

The IVBSS Initiative is a multimodal, two-phase program aimed at working with industry to accelerate the commercial availability of integrated safety systems in the U.S. light vehicle and heavy commercial truck fleets. Integration of individual crash warning functions is expected to improve safety and overall system performance, reduce cost, improve consumer and fleet acceptance, and enhance product marketability. Prototype vehicles will be developed during Phase I, and test vehicles will be

built and field operational tests conducted during Phase II.

Cooperative Intersection Collision Avoidance Systems (CICAS)

NHTSA is participating with FHWA in an effort to develop systems that address intersection collisions. NHTSA is managing a program to develop and evaluate a system that communicates between the road way and vehicle to warn the driver of potential stop sign and traffic signal violations. The CICAS Initiative is designed to employ a combination of vehicle –based technologies and systems, infrastructure-based technologies and systems and communication systems focused on detecting and avoiding potential crossing path crashes at intersections. The major focus of this program is to determine if these systems are effective at reducing crashes while achieving a sufficient level of driver acceptance.

Vehicle Infrastructure Integration (VII)

The goal of the VII Program is to achieve nationwide deployment of a communications infrastructure on the roadways and in all production vehicles to improve transportation and the quality of American life in ways not imagined a generation ago. The fundamental building blocks of the VII concept are coordinated deployments of communication technologies in all vehicles by the automotive industry, and on all major U.S. roadways by the transportation public sector. A VII consortium has been established to determine the feasibility of widespread deployment and to establish an implementation strategy. The consortium consists of the vehicle manufacturers, AASHTO, ten State Departments of Transportation, and the U.S. DOT.

Human Factors Research

In the human factors area, NHTSA has been focusing on the role of the driver vehicle interface in determining the effectiveness and driver acceptance of advanced vehicle safety technologies (AVST), such as collision warning systems (CWS). The ability of drivers to recognize, understand, and properly respond to the visual, auditory, and other feedback from these technologies is influenced by the degree to which their designs are compatible with drivers' capabilities. Proper designs will allow drivers to achieve the optimum safety benefit, whereas poor designs can limit or extinguish any advantage.

To help address the research needs in this area, NHTSA organized a Forum on Human Factors Research Necessary to Support Advanced Vehicle Safety Technologies. The Forum focused on five major topics: 1) the compatibility of the technology with the capabilities of the driving population; 2) how to minimize unintended consequences; 3) how to integrate multiple technologies and their interfaces to minimize driver confusion and maximize driver acceptance; 4) the need for standardization of system operation and interfaces; and 5) what are the next steps and mechanism for future collaboration to complete the needed research and achieve the necessary requirements for these types of driver assistance systems. NHTSA has posted the presentations and summary of the Forum on its website.

Belt Minders

NHTSA is close to completing its assessment of the effectiveness and acceptance of enhanced safety belt reminder systems. We observed belt use in thousands of recent model vehicles and compared belt use in vehicles with and without an enhanced reminder system that many manufacturers are installing. We are also exploring the tradeoff between how effective the reminders can be with the acceptability of the reminders to drivers.

Driver/Vehicle Performance and the 100-Car Naturalistic Study

Last year, NHTSA published results from the first large scale instrumented vehicle study to provide insights into the pre-crash behaviors of drivers. The data were obtained from volunteers in the Northern Virginia region who drove their own or leased vehicles for about a year. The study resulted in about 80 crashes and 760 near crashes. Among the findings were that nearly 80 percent of the crashes and 65 percent of near crashes involved driver inattention. Visual inattention was a contributing factor for almost all rear-end crashes. Driver drowsiness was a contributing factor in 20 percent of the crashes and 16 percent of the near crashes. The full reports are available on the NHTSA website.

Backover Crashes

The problem of passenger vehicles backing over pedestrians is a small but significant problem. Last year, NHTSA prepared a report to Congress describing our current estimates of the extent and nature of the problem as well as our test results of current parking aids. The size of the safety problem can only be roughly estimated because many of the backover crashes that occur on private property are not recorded in State or Federal crash databases, which focus on crashes occurring in traffic-ways.

Supplementing NHTSA crash records with death certificate reports, backover crashes involving all vehicle types are estimated to cause at least 183 fatalities annually in the U.S. Testing showed that the performance of sensor-based (ultrasonic and radar) parking aids in detecting child pedestrians behind the vehicle was typically poor, sporadic and limited in range. Because of the potential that camera-based systems appear to offer in addressing the risk of backover, NHTSA plans to conduct additional work to estimate the effectiveness of such systems and to develop specifications of performance for any technology that could be developed to address this risk. Further, the Agency plans to encourage vehicle manufacturers to continue to develop systems that can be effective in addressing this risk at a reasonable cost to the consumer.

Headlighting Research

Driver complaints about headlamp glare affecting their vision continue to be a concern in the U.S. To address this concern and look for solutions that balance the need for increased visibility with the glare consequences that can result, NHTSA has been funding research to identify the factors affecting glare. One of the key objectives is to identify the appropriate driver performance metrics to best evaluate the safety consequences of glare. In July 2004, NHTSA held a workshop on glare metrics and has been utilizing the insights from that workshop in its ongoing research at the Rensselaer Lighting Research Center. Among the topics they are addressing are the effects on driver performance of light spectrum, glare exposure, misaim, and beam pattern. Because adaptive headlighting systems may offer a solution to increasing visibility while minimizing glare, one research task will be to develop a prototype, safety-based system that automatically adjusts the lighting levels in response to driver visual needs and those of oncoming drivers.

Data Collection and Analysis

NHTSA conducts a motor vehicle crash data collection program through the National Center for Statistics and Analysis (NCSA). It is composed of: the data collected from the states, including Fatality Analysis Reporting System (FARS) and the State Data Program, crash investigations, which includes the National Automotive Sampling System (NASS) and the Special Crash Investigations (SCI) programs.

FARS is a census of all fatal crashes occurring on public roads in the United States. The **NASS** is comprised of the General Estimates System (GES) and the Crashworthiness Data System (CDS). The GES provides national estimates of characteristics of all motor vehicle crashes. The CDS conducts detailed investigations into a nationally representative sample of crashes involving towed passenger vehicles to investigate injury-causing mechanisms and to evaluate countermeasures. The SCI program provides in-depth data on crashes where emerging issues may be of interest.

A new NHTSA initiative called the **National Motor Vehicle Crash Causation Survey** (NMVCCS) began collecting data starting in January 2005. This survey conducts on-scene crash investigations and collects data from a nationally representative sample of passenger vehicle (passenger cars, vans, sport utility vehicles, pickups and other light trucks) crashes. The data provide information on the events and factors related to the causation of crashes. The survey will help identify the events and factors related to how crashes occur.

NCSA also conducts key analyses of the collected data and publishes reports, including the Traffic Safety Facts Annual Report and Traffic Safety Fact Sheets. Copies of the most recent reports can be found at NCSA's web site using the following URL: http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/AvailInf.html

Significant Rulemaking Actions

Truck Tractor Stopping Distance

On December 15, 2005 NHTSA published an NPRM to reduce stopping distance for truck tractors. A final rule is expected to be published in 2007.

Electronic Stability Control for Light Vehicles

On September 18, 2006 NHTSA issued a NPRM to require auto manufacturers to install electronic stability control (ESC) as a standard feature on all new passenger vehicles under 10,000 pounds starting with the 2009 model year and to have the feature available as standard equipment on all vehicles by the 2012 model year.

Light Truck Fuel Economy Final Rule and CAFE Reform Proposal

In August 2005, the agency published a NPRM and on April 6, 2006 a final rule, to establish higher CAFE standards for light trucks for MYs 2008-2011 and reforming the structure of the CAFE program for light trucks. The reform is based on vehicle size. During a transition period of MYs 2008-2010, manufacturers may comply with CAFE standards established under the reformed structure or with

standards established in the traditional way. In MY 2011, all manufacturers would be required to comply with a Reformed CAFE standard. The stringency of the reformed CAFE depends on each manufacturer's fleet mix of vehicles.

In May 2006, the Administration sent proposed legislation to Congress asking for authorization to amend the automobile fuel economy provisions of title 49, United States Code, to reform the setting and calculation of fuel economy standards for passenger cars. No action was taken to pass the bill in the 109th Congress.

In the State of the Union Address in January 2007, President Bush announced a plan to reduce gasoline consumption from passenger automobiles by up to 8.5 billion gallons in 2017. The President's plan calls for reforming and increasing CAFÉ standards for model year 2010-2017 passenger cars, and for further increasing light truck and SUV standards for model years 2012-2017.

Event Data Recorders

NHTSA published a final rule on August 28, 2005, that specified uniform requirements for the accuracy, collection, storage, survivability, and retrievability of onboard motor vehicle crash event data in passenger cars and other light vehicles equipped with event data recorders (EDRs). This final rule responded to the growing practice in the motor vehicle industry of voluntarily installing EDRs in an increasing number of light vehicles. The rule is intended to standardize the data obtained through EDRs so that such data may be put to the most effective future use and to ensure that EDR infrastructure develops in such a way as to speed medical assistance through providing a foundation for automatic crash notification (ACN).

Occupant Crash Protection – 5th Percentile Female Dummy Belted Barrier Crash Test

NHTSA published a final rule on August 31, 2006, amending its safety standard on occupant crash protection to establish the same 56 km/h (35 mph) maximum speed for frontal barrier crash tests using belted 5th percentile adult female test dummies as we previously adopted for tests using belted 50th percentile adult male dummies. The agency is adopting this amendment to help improve crash protection for small statured occupants. The new requirement is phased-in in a manner similar to the phase-in for the 56 km/h (35 mph) maximum speed test requirement using the 50th percentile adult male dummy, but beginning 2 years later, i.e., September 1, 2009.

Anthropomorphic Test Devices; ES-2re Side Impact Crash Test Dummy 50th Percentile Adult Male and SID-IIs Side Impact Crash Test Dummy 5th Percentile Adult Female

NHTSA published final rules on December 14, 2006, amending the agency's regulation on anthropomorphic test devices. One rule added specifications and qualification requirements for a new mid-size adult male crash test dummy, called the "ES-2re" test dummy. The ES-2re dummy has enhanced injury assessment capabilities compared to devices existing today, which allows for a fuller assessment of the types and magnitudes of the injuries occurring in side impacts and of the efficacy of countermeasures in improving occupant protection.

The other rule added specifications and qualification requirements for the 5th percentile adult female crash test dummy, called the SID-IIs Build Level D ("SID-IIs") test dummy. The SID-IIs dummy is instrumented in the head, thorax, abdomen and pelvis, which enables it to assess in a comprehensive manner the performance of vehicles in protecting small-stature occupants in side impacts.

NHTSA plans to use both the ES-2re dummy and the SID-IIs dummy in an upgraded Federal motor vehicle safety standard on side impact protection.

Vehicle Safety Priorities Plan

In July 2003, the agency published its first Vehicle Safety Rulemaking and Supporting Research Priorities Plan. The agency published an update to that plan in January 2005. A new update is planned for 2007 and will cover the period 2007 to 2010 and will include all areas of Vehicle Safety, including Enforcement. The plan will include safety actions that the agency believes will offer the greatest potential for saving lives and preventing injury, improvements in CAFE, and pursuit of International Harmonization activities.

For the period 2007-2010, the agency's rulemaking priorities will address: rollover prevention and protection in rollover crashes, vehicle crash compatibility, back-over protection for children, reduce light vehicle tire failures, make large trucks safer, and CAFE.

Priority research will support the priority rulemaking areas and will pursue additional priority research

areas including: improved restraint systems; Advanced Technology – Integrated Safety; Human Injury and Applied Biomechanics; Hydrogen, Fuel Cell and Alternative Fuel Vehicle Safety; crash avoidance for heavy vehicles and tires; Advanced Collision Avoidance Technologies; and Vehicle Safety Communications.

Priority vehicle safety consumer information actions are consideration of changes to the frontal and side test programs, and providing consumers with additional crash avoidance information. NHTSA published a report titled, "The New Car Assessment Program Suggested Approaches for Future Program Enhancements," in January 2007. The report outlines both near and long-term approaches that the agency is considering to further enhance the New Car Assessment Program (NCAP).

Summary and Conclusions

In 2005, 43,443 fatalities occurred in the U.S. as a result of motor vehicle crashes. The fatality rate based on vehicle miles traveled was 1.45 per 100 million VMT. Motorcycles have seen a major increase in rider fatalities, numbering 4,553 in 2005.

The total number of police-reported crashes in the U.S. in 2005 was estimated to be 6.2 million, resulting in 2.7 million persons being injured.

In 2005, safety belt use usage rate was about 81 percent for outboard-seated occupants observed during daytime hours.

NHTSA continues to use an integrated approach to vehicle safety, combining engineering, educational, and enforcement programs that are major contributors to total vehicle safety.

But the near future holds a major shift in demographics. Rider age in the U.S. is increasing, as the baby boomer generation starts to reach retirement. Rollover crashes, partly fueled by strong sales of LTVs, continue to cause major harm in U.S. traffic crashes, accounting for about 1/3 of the occupant deaths. Frontal and to a lesser extent, side crashes are also major contributors to loss of life on our highways. Crash compatibility between vehicles of different sizes need to be addressed.

The emerging technologies, as recently demonstrated by ESC, have a high potential of helping to meet the safety needs in the US. Accelerating the introduction of those technologies that are truly effective will provide safety benefits. The research results can support rulemaking, consumer information programs, ratings, and other programs. Thus, NHTSA research needs to be engaged in ensuring that these new technologies are properly deployed to maximize their safety capability.

NHTSA's Office of Vehicle Safety Research has laid out the following 10 research objectives:

- Identify opportunities for safety enhancement
- Develop an understanding of the performance of advanced technologies
- Address driver vehicle safety issues related to advanced technologies
- Develop performance and objective tests to establish the effectiveness of advanced technologies
- Advance human injury research through leadership and establishment of injury criteria, test devices, and procedures
- Enhance safety of heavy vehicles
- Identify safety issues related to alternatively fueled vehicles
- Improve motorcycle safety
- Enhance pedestrian safety
- Address impaired, drowsy, and distracted driving safety

To coordinate our efforts, NHTSA periodically publishes vehicle safety priorities plan. The plan includes safety actions that the agency believes will offer the greatest potential for saving lives, preventing injury, and preventing crashes.

For the period 2007-2010, the agency's vehicle safety priorities will address:

- Rollover prevention
- Protection in rollover crashes
- Vehicle crash compatibility
- Back-over protection for children
- Light vehicle tire failures
- Large trucks
- Corporate Average Fuel Economy