EXECUTIVE SUMMARY HIGHWAY SAFETY RESEARCH: A NATIONAL AGENDA

Motor vehicle-related injury and death is the nation's largest public health problem. The economic costs to society will approach \$2 trillion and an even greater intangible human loss will occur to family and friends of the 33 million victims.

The nation's apparent wholesale commitment to safety has not resulted in significant reductions in deaths, injuries and crashes. One reason is the increasing demand on the transportation system. A second reason is that the knowledge or insight needed to reduce crashes and mitigate their consequences using cost-effective and socially acceptable strategies is hampered by shrinking research dollars and failure to develop and fund effective implementation plans. The human and economic consequences of motor vehicle crashes are unaffordable and unacceptable. Furthermore, the nation's progress has slowed almost to a halt. The majority of motor vehicle crashes are predictable and preventable. The carnage is unnecessary.

The current research effort is compromised by a number of factors including fragmentation, minimal coordination and partnership activities, redundancies of effort, critical gaps and failure to implement research findings. This document proposes a new research agenda that not only addresses research themes focused on areas with the greatest potential to reduce crashes but also suggests a reinvention of the research process by encouraging sponsoring organizations to work collaboratively in the search for effective solutions to specific safety concerns.

THE HIGHWAY SAFETY RESEARCH AGENDA

Vision: The vision of the National Research Agenda is to bring about a profound reduction in deaths, injuries and crashes generated from the successful development and implementation of an integrated, cost-effective strategic highway safety research agenda.

Mission: The vision will be realized by identifying the most promising short, mid and long-term research, development and implementation activities that result in precipitous reductions in deaths, injuries and crashes. These activities will integrate the interaction of users, vehicles and roadways into a safer highway transportation system.

Guiding Principles:

Focused -- Identifies and addresses safety research, development and implementation activities. *Efficient* – Utilizes existing safety research plans.

Comprehensive - Addresses safety management as well as individual system components.

Effective – Emphasizes advanced technologies and other activities with high potential.

Consensus-based - Utilizes consensus strategies to guide recommendations.

Time-framed – Addresses both short and long term issues.

Customer Driven – Incorporates end users in the process.

Proposed Research Process

The Agenda focuses attention not only on research gaps but also on the research process itself. Increased communication and a more coordinated program will dramatically increase the effectiveness of the overall results.

Formulating the Research Program

The Agenda proposes a coordinated, efficient and cost effective research program with research sponsors, researchers and user groups meeting regularly to collectively identify research gaps, explore methods for addressing research needs, define research project initiatives, funding requirements and organizational champions and monitor findings of completed projects.

Performing Research

The Agenda encouraged organizations to funnel their resources and activities into closing identified gaps and to operate quality assurance processes to improve the effectiveness of their research efforts.

Implementing the Findings

End users are involved in the new research process to ensure implementation planning. It concludes that TRB should compile results from core safety organizations and prepare a report to the Nation and Congress on the overall safety research program on an annual or bi-annual basis.

Safety Research Themes

The Safety Working Group identified eight safety themes with potential for reducing crashes. Experts in each of the areas were recruited to develop "white papers" on each of the themes.

Safety Management and Data Systems

Organization and management of safety, both operations and research, is crucial for optimal problem identification, solution development and application and outcome evaluation. The Intermodal Surface Transportation Equity Act (ISTEA) mandated a safety management system in each state, but it was changed to a voluntary system two years later. Some states have continued and built these systems into a highly useful management tool; others have not.

Research Needs

- Develop recommendations for implementing research and evaluation results
- Develop case studies and guidelines for safety management practices and principles
- Expand current initiatives to improve the collection, management and analysis of crash data
- Perform crash causation research

Driver Competency

There is a widely held belief that driver competency, i.e. the ability to drive in a proficient manner, is directly related to safety. While simple enough in concept, the notion of competency is complex, subject to many interpretations and known to interact with many other factors that influence safety.

Research Needs

- Solve the problems of novice drivers
- Develop countermeasures for managing inattention
- Enhance safe mobility for older drivers
- Create learning opportunities and resources to improve driver skills

High-Risk Drivers

Numerous studies have documented that driver behavior is the major contributory factor in motor vehicle crashes. Research has also demonstrated that driver behavior is the most difficult aspect of the transportation system to manage. Purposeful risk taking by drivers is one element of driver behavior known to contribute significantly to crash involvement.

Research Needs

- Reduce impaired driving by targeting drivers with high blood alcohol content
- Increase child and adult restraint use
- Enhance the effectiveness of automated enforcement equipment
- Prevent unlicensed/revoked drivers from driving
- Curb aggressive driving
- Attain a deeper understanding of risk-taking characteristics

Light Duty Vehicle Safety

Drivers of racecars routinely survive catastrophic crashes on the racetrack. Similar crashes involving today's conventional light duty vehicles too frequently result in death. Enhanced levels of crash survival are possible with improvements in vehicle crashworthiness. Moreover, the vast majority of crashes that do occur are precipitated by driver error. And here too, improvements in vehicle design can assist a driver in compensating or recovering from these errors.

Research Needs

• Enhance crash avoidance capabilities through improvements in vehicle handling and stability, braking and

traction control, conspicuity, lighting and signaling

- Increase understanding of the human/machine interface in light duty vehicles
- Enhance the crash survivability of vehicles through improvements in restraint system designs and passenger compartment integrity.
- Increase the understanding of vehicle compatibility in motor vehicle safety
- Develop improved biomechanics evaluation protocols and crash dummies
- Improve driver fitness monitoring technology and apply it to the future vehicle fleet
- Improve the safety of children in vehicles
- Monitor the performance of vehicles in the field through data analysis and crash investigations

Highway Infrastructure and Operations

One-third of all motor vehicle fatalities occurs when a vehicle leaves the road. Almost one-fourth of all vehicle fatalities happen at intersections and the number of work zone deaths remains a high profile concern. The highway infrastructure is a contributor to the number and severity of crashes – as much as 15-20 percent of all crashes and highway fatalities.

Research Needs

- Develop a comprehensive set of human factor safety guidelines that can be incorporated into the design, operation and maintenance of highways
- Perform research to more effectively reduce the consequences of leaving the road
- Improve intersection safety
- Continue the intelligent infrastructure initiative
- Improve safety in work zones
- Conduct research necessary to develop the "Highway Safety Manual" a tool to automate the inclusion of safety in the highway design process

Vulnerable Road Users

According to the National Highway Traffic Safety Administration's 2000 Motor Vehicle Traffic Crashes Injury and Fatality Estimates Early Assessment, 4,727 pedestrians, 738 pedalcyclists, and 2,680 motorcyclists died in motor vehicle crashes and approximately 194,000 were injured. The provision of appropriate facilities for pedestrians and bicyclists is crucial for reducing the number of injuries and fatalities.

Research Needs

- Improve crash and use data regarding walking, bicycling and motorcycling
- Develop accommodations to allow safer road sharing for pedestrians and bicyclists
- Develop methodologies to evaluate the safety and operational effectiveness of off-road facilities designed for pedestrians and bicyclists
- Increase visibility and conspicuity of vulnerable road users
- Develop educational materials

Truck and Bus Safety

About 13 percent (5,374) of the 1998 fatalities and 4 percent (127,000) of the injuries involved large trucks. The public importance of commercial vehicle safety is underscored by the fact that approximately two-thirds of all "harm" from large truck crashes, and approximately 85 percent of fatalities occur "outside of" the truck, i.e., to other vehicles and vehicle occupants involved in crashes with trucks.

Research Needs

- Increase the understanding of truck and bus crashes and their precursors
- Reduce both car and truck driver errors resulting in car/truck crashes
- Promote heavy vehicle safety equipment and technologies
- Improve the enforcement of commercial motor carrier safety regulations
- Identify and reduce the crash risk of high-risk carriers and drivers
- Improve commercial driver training and performance management
- Improve driver alertness and fatigue management
- Improve driver physical and medical fitness
- Improve the highway infrastructure and operations in regard to truck and bus safety

Post-Crash Management

Emergency medical systems (EMS) transport almost 85 percent of persons involved in fatal crashes to emergency departments and 30 percent are admitted to the hospital. Although the development of trauma systems, which

includes a pre-hospital care component, has a demonstrated mortality impact, the exact contribution that is made by pre-hospital care to mortality reduction is unknown. Furthermore, there is essentially no meaningful data on the impact that pre-hospital care has on non-mortality outcome measures for motor vehicle crash victims. EMS care may have an impact on the ultimate level of disability these victims will have, the discomfort they experience and ultimately, the cost that society must pay for medical treatments, lost wages and rehabilitation.

Research Needs

- Identify effective EMS interventions for MVC victims in the United States
- Identify measures that improve trauma system effectiveness
- Identify interventions and technologies associated with better outcomes
- Identify the role that intelligent vehicle systems will have on EMS operations
- Develop simulated patient training using emerging electronic technology

Research Investment

To address the most serious research gaps in each of the eight themes, a panel of experts was poled regarding the amount of funding needed, in addition to existing levels, to support a more aggressive safety research program. The experts agreed that \$80-150M dollars, in addition to current funding levels, per year over a five-year period would stimulate the development of knowledge and products necessary to reduce injuries and deaths. The upper limit \$150M, is needed to make a significant leap forward while the minimum level, \$80M, considers the realism of competing priorities. Minimal investment, compared to the estimated \$191B dollar cost of highway crashes each year, will create the foundation to significantly reduce losses in future years.

Research Benefits

- A deeper understanding of the characteristics and causes of crashes in critical categories that can lead to new and more effective countermeasures
- More efficient and effective safety decision-making processes at the state and local level based upon the development of effective safety management systems
- Improved cost-effective mechanisms to upgrade the safe driving skills and characteristics of young drivers
- Enhanced mechanisms that the driving population can easily accept and adopt to reduce the growing problem of inattentive driving
- Cost effective and publicly supported strategies that drivers and state/local governments can implement to
 reduce the incidence of aggressive driving
- Countermeasures that are effective and broadly supported by the general public to remove suspended or revoked drivers from the roadways
- Safer vehicle designs that can improve the survivability of severe crashes, reduce the likelihood of fire and give the driver additional capability to avoid crashes
- Highway design engineers who use human factors research and training to design safer roadways
- A "smarter" infrastructure that provides motorists with essential driving information at critical locations and times
- More roadways that safely accommodate pedestrians, bicyclists and motorcyclists.
- Fewer fatigued drivers on the highway
- Improved post-crash management systems and techniques to increase survivability in severe crashes, especially in rural areas

HIGHWAY SAFETY RESEARCH: A NATIONAL AGENDA

INTRODUCTION



Motor vehicle-related injury and death is the nation's largest public health problem. The map below graphically depicts the results that will occur over the next decade given the current trend. The States that are shaded include Alaska, Arizona, Connecticut, Delaware, Washington DC, Hawaii, Idaho, Iowa, Kansas, Maine, Mississippi, Montana,

Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Oregon, Rhode Island, South Dakota, Utah, Vermont, West Virginia and Wyoming. The economic costs to society will approach \$2 trillion, a sum most of us cannot even fathom. An even greater intangible human loss will occur to family and friends of the 33 million victims. This loss is unacceptable. The nation must find solutions that will drastically alter the predicted outcome.

Safety is a priority in America. National and state customer surveys confirm that drivers rate highway safety a top transportation concern. Many states also place safety at the top of their list of priorities. The U.S. automobile manufacturing industry has demonstrated its commitment by

incorporating safety features in new vehicles. However, this apparent wholesale commitment to safety has not resulted in significant reductions in deaths, injuries and crashes.

One reason for the lack of progress is because of the increasing demand on the transportation system. According to the 1995 Nationwide Personal Transportation Survey, the number of multi-vehicle households has increased from 31 percent in 1969 to nearly 60 percent of all households in 1995. People are driving more miles each year resulting in congested roadways. Over the past 15 years, vehicle miles traveled has increased 35%, yet new road mileage has risen a mere 1%. With "just in time delivery" trucks have become rolling warehouses. E-commerce introduced a new dimension including phenomenal increases in truck deliveries to neighborhoods. Vehicles are now being equipped with a plethora of electronic devices that may help, but could also complicate the driving task. These increasing demands all but negate safety gains realized from successful initiatives such as an increase in safety belt use and a reduction in impaired driving.

A second reason is that the knowledge or insight needed to reduce crashes and mitigate their consequences using cost-effective and socially acceptable strategies is hampered by shrinking research dollars and failure to develop and fund effective implementation plans. New knowledge, insight or clearer vision must be developed from targeted effective research.

Prior to the 1960's, approaches to highway safety were generally based on myth, conventional wisdom and local custom. During that era more comprehensive approaches based on scientific research principles and methods began to develop. Knowledge produced since then has had a profound influence on funding priorities, as well as program development, implementation and evaluation. Science is not the only basis for making policy decisions, but we have known for centuries that it is the most effective and efficient method compared to all others. The results overwhelmingly demonstrate the benefits of the approach. The motor vehicle fatality rate per 100,000 population according to the National Safety Council's Injury Facts has steadily declined since the implementation of science-based research from 20.1 in 1988 to 15.2 in 1998. Even with dramatic rate reductions, the continuing traffic growth resulted in little change of annual fatality and injury numbers over the past several years.

A considerable national safety research effort is currently underway. Significant resources from the federal, state and private sector levels are being invested. However, the effort is compromised by a number of factors including fragmentation, minimal coordination and partnership activities, redundancies of effort, critical gaps and failure to implement research findings.

This document proposes a new research agenda that not only addresses research themes focused on areas with the greatest potential to reduce crashes but also suggests a reinvention of the research process by encouraging sponsoring organizations to work collaboratively in the search for effective solutions to specific safety concerns. A gain in overall research funding also is needed to effectively address the magnitude of the problem and produce the level of knowledge necessary to achieve a substantial reduction in injuries and deaths.

While there are no guarantees for success, the human loss is so great that a bold initiative is mandatory. The effort requires a relatively minimal investment compared to the massive consequences of crashes. Simply stated, it is the right thing to do.

AGENDA DEVELOPMENT

Responsibility for developing a national agenda for highway safety research is assigned to the Safety Working Group, a component of the national initiative known as the Research and Technology Partnership. Tom Bryer, Pennsylvania and Leanna Depue, Missouri chair the Working Group.

The Working Group hosted a National Safety Agenda Workshop in January 2000. Thirtyeight participants representing government -- Federal, State and Local – academe, highway safety associations, advocacy groups and the private sector attended. The goals were to review existing safety research, develop vision and mission statements and identify major research themes. Experts gave presentations on these issues and their comments were supplemented by small group discussions and examination of other strategic research plans prepared by AASHTO, FHWA, NHTSA, MCSA and others. The meeting participants assigned the responsibility for moving the initiative forward to a core group of individuals.

The core group met in February and April to refine the vision and mission, specify the research themes and research needs for incorporation into a national agenda, identify volunteers to draft white papers on each of the themes and review progress. The draft national research agenda and the theme papers were made available on the web for review and comment by a broadly representative sample of highway safety professionals.

In August 2000, the core group hosted a Safety Research & Technology National Forum. Thirty-six participants representing 27 safety organizations came together to discuss improvements to the research process and refine the research needs associated with each of the theme. The final steps include revisions to the National Agenda and themes based on input from the Forum and web comments, a final round of review through safety organizations, individuals and web-based commentary, publication of the National Agenda and theme papers and implementation of the research programs to improve not only the process but also the practice of current highway research endeavors.

THE HIGHWAY SAFETY RESEARCH AGENDA

The Working Group utilized a strategic planning approach to develop the Agenda. This approach led to the development of a Vision, a Mission and a set of Guiding Principles. They are as follows.

Vision

The vision of the National Research Agenda is to bring about a profound reduction in deaths, injuries and crashes generated from the successful development and implementation of an integrated, cost-effective strategic highway safety research agenda.

Mission

The vision will be realized by identifying the most promising short, mid and long-term research, development and implementation activities that result in precipitous reductions in deaths, injuries and crashes. These activities will integrate the interaction of users, vehicles and roadways into a safer highway transportation system.

Guiding Principles

The Agenda is based upon a set of foundational ideals. These principles guided the process for the strategic development of this document.

- Focused -- Identifies and addresses key safety research, development and implementation (RD&I) activities.
- Efficient -- Utilizes existing safety research plans.
- Comprehensive Addresses safety management systems in general as well as driver, vehicle, highway, pedestrian, bicycle, motorcycle, truck, bus and EMS safety issues.

- Effective Emphasizes RD&I activities, including the application of advanced technologies, with dramatic potential to reduce deaths, injuries and crashes.
- Consensus-based Utilizes consensus building strategies to guide problem identification and recommendations.
- **Time-framed** Addresses both short and long term issues.
- Customer Driver Incorporates end users in the process to ensure their ideas and support are forthcoming during the implementation phase.

The major products of this strategic planning approach are an enhanced research process and the establishment of eight research themes.

Proposed Research Process

Considerable safety research efforts are underway by federal and state government agencies, universities, non-profits and the private sector. The Safety Working Group is focusing attention not only on the safety research gaps but also on the research process itself. They believe that the process eventually dictates both the product and the likelihood of its implementation. Increased communication and a more coordinated program will dramatically increase the effectiveness of the overall results.

The Department of Transportation and others have processes in place to promote these basic principles. There is still, however, a level of disconnect among the research efforts of the federal, state, and university center research programs, the non-profits and the private sector. The consequence is redundancy in some areas and gaps in others. Opportunities for improving the research, development and implementation processes exist that, when implemented, will result in several positive outcomes.

- Focused and integrated research efforts.
- Resources targeted to areas with the greatest potential for improving safety.
- Increased formal collaboration and coordination among the federal, state, university and private research organizations.
- More opportunities for developing an integrated approach to the crash problem.
- Increased input from end users.
- Increased consideration and development of implementation strategies throughout the research process.
- More efficient, rapid and effective implementation of safety innovations.

To take advantage of these identified opportunities, the Working Group developed a proposed research process that has the potential to significantly increase the effectiveness of the overall research effort.

The proposed research process occurs over three distinct stages:

- 1. Formulating a coordinated research plan.
- 2. Conducting research and creating new knowledge and products.
- 3. Implementing research findings and products to reduce crashes, injuries and deaths.

This linear process is a valid approach, however, there is considerable overlap and feedback among the three stages.

Formulating the Research Program

To develop a coordinated, efficient and cost effective research program, research sponsors,

researchers and user groups for each research theme should meet on an annual or bi-annual basis, well in advance of research program development activities. The purpose of these meetings would be to collectively identify research gaps that limit our ability to reduce injuries and deaths; explore methods for addressing research needs and gaps by various funding organizations; define research project initiatives, funding requirements and organizational champions to close the gaps; and monitor important findings and products of completed research projects.

Opportunities to organize joint efforts among research organizations can also be explored at this time. Representatives from federal and state agencies (including both highway and highway user representatives), university transportation centers specializing in highway safety, Transportation Research Board staff and other major non-governmental safety organizations should participate in this effort. States and university transportation centers will be encouraged to identify representatives to participate and communicate results to their peers. It is proposed that the Transportation Research Board organize and manage this collaborative effort and prepare a document that organizations can use as a blueprint to address critical research gaps.

When research organizations have developed preliminary safety research plans, they should be encouraged to afford other safety organizations and user groups the opportunity to review and comment. Comments should be routinely considered and incorporated as appropriate.

Performing Research

Once the collaborative research blueprint is developed, research partners are encouraged to funnel their resources and activities into closing the identified gaps. It is suggested that a quality assurance process be actively operating within each sponsoring organization striving to improve the effectiveness of their research effort. For example, this process may include the establishment of an internal peer-review panel to critically evaluate proposed research

methodologies as well as the expected impact of specific research strategies on crashes, injuries and deaths, an oversight panel to monitor the research program progress, and an end-user focus group to further refine the research process and implementation strategy. It may be appropriate to utilize other research organization participants, such as external partners or even customers, as part of the review panel effort. Inclusion of the end user is highly encouraged in each research phase. To enhance the success of the research products and findings, each partner is urged to view the development of an implementation plan as an integral part of the research project. If the research project is part of an integrated effort, each organization should involve the other in the initiative.

Implementing the Findings

The sponsoring agency, at or near completion of the research, should assess the findings in terms of potential implementation. Routine, multi-stage project assessment is encouraged. This assessment will consider the value of the findings for reducing injuries and deaths, the difficulty and cost of implementation and targets for specific opportunities. To facilitate the effective delivery of new products and knowledge, end users should be involved in the assessment process and an implementation plan should be developed early in the life of the project. The process phase should also include a budgeted implementation phase that may include workshops, presentations or on-the-job training to facilitate the incorporation of research findings into appropriate work functions.

Each sponsor should prepare a final report summarizing their research effort, funds invested, new knowledge or products identified, implementation approach and results and probable impact on reducing injuries and deaths. The report should be made available to all safety organizations and user groups.

TRB should compile results from core safety organizations and prepare a report to the Nation and Congress on the overall safety research program on an annual or bi-annual basis. The report should reflect important findings and products, implementation actions, probable impact on injuries and deaths, successes in closing critical research gaps identified in the collaborative research blueprint and integration achievements.

Safety Research Themes

The Safety Working Group utilized a comprehensive approach and identified eight major safety themes. These themes are data and research driven and hold great promise for reducing fatalities, injuries and crashes. The eights themes are as follows:

- Safety Management and Data Systems
- Driver Competency
- High Risk Driving
- Light Duty Vehicle Safety
- Highway Infrastructure and Operations
- Vulnerable Road Users
- Truck and Bus Safety
- Post-Crash Management

Within each theme, a targeted set of research needs was identified as outlined in Table 1.

Expanded concept papers for each theme are located in Appendix A.

Table 1: Themes and Research Needs

Theme	Research Needs			
Safety Management and Data Systems	 Develop recommendations for implementing research and evaluation results Develop case studies and guidelines for safety management practices and principles Expand current initiatives to improve the collection, management and analysis of crash data Perform crash causation research 			
Driver Competency	 Solve the problems of novice drivers Develop countermeasures for managing inattention Enhance safe mobility for older drivers Create learning opportunities and resources to improve driver skills 			

High Risk Drivers	 Reduce impaired driving by targeting drivers with high blood alcohol content Increase child and adult restraint use Enhance the effectiveness of automated enforcement equipment Prevent unlicensed/revoked drivers from driving Curb aggressive driving Attain a deeper understanding of risk-taking characteristics
Light Duty Vehicle Safety	 Enhance crash avoidance capabilities through improvements in vehicle handling and stability, braking and traction control, conspicuity, lighting and signaling Increase understanding of the human/machine interface in light duty vehicles Enhance the crash survivability of vehicles through improvements in restraint system designs and passenger compartment integrity. Increase the understanding of vehicle compatibility in motor vehicle safety Develop improved biomechanics evaluation protocols and crash dummies Improve driver fitness monitoring technology and apply it to the future vehicle fleet Improve the safety of children in vehicles Monitor the performance of vehicles in the field through data analysis and crash investigations

Theme	Research Needs			
Highway Infrastructure and Operations	 Develop a comprehensive set of human factor safety guidelines that can be incorporated into the design, operation and maintenance of highways Perform research to more effectively reduce the consequences of leaving the road Improve intersection safety Continue the intelligent infrastructure initiative Improve safety in work zones Conduct "gap" research necessary in the development of the "Highway Safety Manual" – a tool to automate the inclusion of safety in the highway design process 			
Vulnerable Road Users	 Improve crash and use data regarding walking, bicycling and motorcycling Develop accommodations to allow safer road sharing for pedestrians and bicyclists Develop methodologies to evaluate the safety and operational effectiveness of off- road facilities designed for pedestrians and bicyclists Increased visibility and conspicuity of vulnerable road users Develop educational materials 			
Truck and Bus Safety	 Increase the understanding of truck and bus crashes and their precursors Reduce both car and truck driver errors resulting in car/truck crashes Promote heavy vehicle safety equipment and technologies Improve the enforcement of commercial motor carrier safety regulations Identify and reduce the crash risk of high-risk carriers and drivers Improve commercial driver training and performance management Improve driver alertness and fatigue management Improve driver physical and medical fitness Improve the highway infrastructure and operations in regard to truck and bus safety 			
Post-Crash Management	 Identify effective EMS interventions for MVC victims in the United States Identify measures that improve trauma system effectiveness Identify interventions and technologies associated with better outcomes Identify the role that intelligent vehicle systems will have on EMS operations Develop simulated patient training using emerging electronic technology 			

Research Investment

Injury in America: A Continuing Public Health Problem (1983), states "The nation needs a coordinated injury research program with clear objectives and more focus on critical needs, with adequate funding, and with the support of congress and the executive branch."

The book acknowledges that even though injuries are responsible for more economically productive years of life lost than heart disease and cancer combined, the federal expenditure for research in injury control is relatively small. Concerns addressed in this historical document

remain relevant.

To address the most serious research gaps in each of the eight themes, a panel of experts was poled regarding the amount of funding needed, in addition to existing levels, to support a more aggressive safety research program. The experts agreed that \$80 to \$150M dollars, in addition to current funding levels, per year over a five-year period would stimulate the development of knowledge and products necessary to reduce injuries and deaths. The upper limit,150M, is what the research community believes is needed to make a significant leap forward. The minimum amount, \$80M, considers the realism of competing priorities and is the absolute minimum funding level for producing some useful research products in each of the eight theme areas. The upper and lower funding limits are outlined in Table 2 by theme area. These funding levels do not include implementation funds.

Theme Area	*Investment / Year	Over 5 Years	
Safety Management and Data System	5M - 10M	25M - 50M	
Driver Competency	10M - 20M	50M - 100M	
High Risk Drivers	20M - 40M	100M - 200M	
Light Duty Vehicle Safety	10M - 20M (Beyond Existing ITS/IVI)	50M - 100M	
Highway Infrastructure and Operations	20M - 30M	100M – 150M	
Vulnerable Road Users	5M - 10M	25M - 50M	
Truck and Bus Safety	5M - 10M	25M - 50M	
Post-Crash Management	5M - 10M	25M - 50M	
TOTAL – 8 Theme Areas	80M–150M per Year	400M-750M / 5 Years	

Table 2:	Research	Dollars	by	Theme
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Over the past quarter century, safety related research has contributed to actual reductions in mortality and morbidity rates, documented the effectiveness of many interventions, identified interventions that do not achieve desired results and exposed unintended consequences. An additional 80M dollars per year research investment will help refine interventions and products. A minimal investment, compared to the estimated 191B dollar cost of highway crashes each year, will create the foundation to significantly reduce these loses in future years. The Safety Working Group believes that this level of effort is needed to achieve both the vision and the benefits identified in this document.

Recognizing that funding is scarce, accountability mechanisms will be established and incorporated into the process to help ensure effective use of research dollars to close critical gaps.

Research Benefits

The vision of the Strategic Safety Research Agenda is to bring about a profound reduction in deaths, injuries, and crashes generated from the successful development and implementation of an integrated, cost-effective, research effort. The effort must be significant due to the magnitude and complexity of the crash problem if the vision is to be achieved. This achievement will include an enhanced public awareness of highway safety funding needs and working examples of how crash fatalities and injuries can be eliminated.

While no guarantees can be made, some of the expected products resulting from the research effort are as follows:

Deeper understanding of the characteristics and causes of crashes in critical categories

that can lead to new and more effective countermeasures.

- More efficient and effective safety decision-making processes at the state and local level based upon the development of effective safety management systems.
- Improved cost-effective mechanisms to upgrade the safe driving skills and characteristics of young drivers.
- Enhanced mechanisms that the driving population can easily accept and adopt to reduce the growing problem of inattentive driving.
- Cost effective and publicly supported strategies that drivers and state and local governments can implement to reduce the incidence of aggressive driving.
- Countermeasures that are effective and broadly supported by the general public to remove suspended or revoked drivers from the roadways.
- Safer vehicle designs that can improve the survivability of severe crashes, reduce the likelihood of fire and give the driver additional capability to avoid crashes.
- Highway design engineers who use human factors research and training to design safer roadways.
- A "smarter" infrastructure that provides motorists with essential driving information at critical locations and times.
- More roadways that safely accommodate pedestrians, bicyclists and motorcyclists.
- Fewer fatigued drivers on the highway.
- Improved post-crash management systems and techniques to increase survivability in severe crashes, especially in rural areas.

To achieve these outcomes requires discipline, responsibility, sound research planning, coordination, accountability and funding. The scope of this critical effort is similar to the

1960's commitment to successfully and safely put a man on the moon. The enhanced research process and adequate funding are essential for beginning the journey.

Conclusion

The human and economic consequences of motor vehicle crashes are unaffordable and unacceptable. Furthermore, the nation's progress in one of its largest public health problem areas has slowed almost to a halt. The majority of motor vehicle crashes are predictable and preventable. The carnage is unnecessary. It is completely unconscionable to allow the number of highway-related injuries and deaths projected earlier in this paper to occur without financially committing to a national, cost effective, safety effort to mitigate these numbers. This effort must rely heavily on a bold, expanded research initiative, such as the one proposed in this document to guide effective countermeasure development and implementation.

APPENDIX

RESEARCH THEMES

Safety Management and Data Systems

Driver Competency

High-Risk Drivers

Light Duty Vehicle Safety

Highway Infrastructure and Operations

Vulnerable Road Users

Truck and Bus Safety

Post-Crash Management

SAFETY MANAGEMENT AND DATA SYSTEMS

BACKGROUND

The estimated 41,800 fatalities and 3.2 million injuries in 2000 were not cheap. The comprehensive cost per fatality in 1999, according to the National Safety Council, was slightly over 3M dollars and the comprehensive cost of a incapacitating injury was \$153,453. The total traffic crash cost in 1999 was in the \$181B dollar range. Increasingly the delays from congestion surrounding crash scenes, crashes associated with that congestion, and heightened pollution are other types of cost missing from the dollar figures. Highway design and operation, vehicle design and operation and driver behavior programs directly affect crash experience. Costs and benefits can often be attributed to these elements of highway transportation. Like all operational technical systems there is a "behind the scenes" element that plays a vital role in creating and operating safely. This is management of the safety enterprise. Data feeds this enterprise, but organization and management of safety, both operations and research, is crucial for optimal problem identification, solution development and application and outcome evaluation.

The Intermodal Surface Transportation Equity Act (ISTEA) mandated a safety management system in each state, but it was changed to a voluntary system two years later. Some states have continued and built these systems into a highly useful management tool; others have not. Within states some localities began to deal with highway and traffic safety using safety management system approaches, particularly those in the Safe Communities program. Benefits of using a safety management system approach are difficult to quantify and even harder to link directly to crash reduction. Similarly the value of crash data to support decision making, planning (strategic and tactical) and evaluation cannot be directly linked to cost benefit

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calculations. However, each state and community highway/traffic safety problem can be very individual. Data and management systems need to be in place to aid problem identification, community thinking and decision-making, program implementation and evaluation at every government level.

The best practices documented by FHWA from states with successful safety management programs clearly suggests that coordination, communication, planning and cooperation among the stake holders in highway safety has substantive benefits, Chief among these are:

- Reduction and removal of redundant efforts.
- A clearer focus on effective safety treatments and countermeasures.
- More efficient use of safety resources.
- More efficient and effective program delivery through improved coordination.
- More informed policy discussion and decisions.
- A central organization within the state for management of highway safety issues.

These same benefits can be expected at the local level if safety management best practices and principles are exported.

RESEARCH NEEDS

Develop Recommendations for Implementing Research and Evaluation Results

Research implementation is a nebulous process at best. The traditional technique is to disseminate research reports and hope people are interested enough to find a way to use the research results.

Current Knowledge and Practice

Some research is implemented through a pilot or demonstration project to show how research findings can be used. Research findings are sometimes incorporated in training programs or

disseminated through technology transfer centers. More recently some state departments of transportation involve the ultimate user in the research process to identify implementation methods. Many organizations are now distributing concise research briefs or newsletters to interested users. At present, there is no systematic method of implementing safety research results at the state or local level.

Rationale

The purpose of this strategy is to develop best practices on successful and innovative methods for implementing safety research results in a more effective, widespread and timely fashion. Another purpose is to identify improved methods for disseminating and using research results so that community and state decisions about highway traffic safety investments and programs are better informed.

Expected Result

- The typical 15-year research to operational application cycle will be dramatically reduced.
- The benefits of research and technology will be more quickly realized.
- The return on research investment will begin sooner and speeding the reduction of crashes.
- More informed decision making at all levels of government.

Develop Case Studies and Guidelines for Safety Management Practices and Principles

The need is to identify states with successful safety management programs and develop case studies to illustrate how these can work as well as the benefits associated with specific safety management organizations and practices. Also, it may prove beneficial to develop case studies from localities in the Safe Communities program. Finally, the research program will pilot test safety management practices in several localities, using the results to develop further case studies for local level application of safety management principles and practices.

Current Knowledge and Practice

There is currently a need to identify, develop and use documented best practices in developing management guidelines for successful safety management operations. Furthermore, the guidelines should be adapted for local use. At present, guidelines and case studies documenting successful safety management practices are not available.

Rationale

It is known that safety management principles and practices are being successfully operated in some states and localities. Identifying these practices and performing technology transfer will assist governments at all levels in improving the systems and ultimately, highway safety in general.

Expected Results:

- Data driven decision making
- Resources focused on the most urgent problems.
- Coordinated safety program development so all relevant parties are participating.
- Improved efficiency and responsiveness of safety efforts throughout the state.
- These same benefits are expected at the local level.

Expand Current Initiatives to Improve the Collection, Management and Analysis of Crash

Data

Highway Safety Information Systems (HSIS) provide data that are critical to the development of polices and programs that enhance the operation and safety of the highway transportation system. Reliable data are essential to guide any changes to this system in a manner that ensures efficient road travel. They are particularly crucial for initiatives focused on improving the safety of the system users.

Current Knowledge and Practice

At the very time when reliance on information systems is increasing, current trends indicate that the ability to provide high quality, reliable information is in jeopardy. Mangers of these complex information systems are facing several challenges. Among these are:

- The ability to stay current with the rapid deployment of innovative products by the information technology industry.
- Funding for new products and maintenance of current systems.
- Meeting the needs of the highway safety community in a dynamic atmosphere.
- Addressing the competing demands for resources

Rationale

Crash data is the basis for both highway safety problem identification and the performance measures to determine effectiveness. Without a reliable, high quality HSIS, we proceed with unsupported assertions that have proven costly and over time, erode support for the existence of these systems. The safety enterprise is then managed blindly. Continued research is needed in a number of areas to improve safety management. The following projects provide two examples of research currently underway.

The National Model for Technology in Highway Safety and Law Enforcement is a joint endeavor of the Federal Highway Administration, the Iowa Department of Transportation and the Iowa Department of Public safety. The purpose of this project is to demonstrate the successful integration of technologies for data collection, management and communication of safety information. The objectives of the National Model are to improve data acquisition for roadway incidents, leverage proven technology for law enforcement, streamline the communication of safety information to key stakeholders and enhance the use of this information for safety programs. New approaches are being used to shorten data collection time, minimize disruption to traffic, increase officer safety and efficiency and improve data quality.

The Transportation Safety Information Management System (TSIMS) is a joint
application development program sponsored by AASHTO on behalf of its member
organizations. The goal of TSIMS is to develop a common information management
infrastructure to support state and local traffic safety information management requirements.
TSIMS is an integration of technologies that provides a data capture subsystem, a virtual
database of traffic safety information and a suite of data analysis and reporting tools to meet
state and local safety analysis and reporting requirements.

Expected Results

The National Model and TSIMS staff is coordinating their safety data initiatives to build on each for greater efficiencies and to avoid redundancy. These safety information efforts should provide:

- Reduction in the overall effort necessary to collect relevant data.
- Electronic data acquisition and dissemination of timely and accurate incident information.
- Common access among agencies to vital incident information including persons involved, severity, weather conditions and location.
- Data transmission and feedback with the court system for citation information and adjudication results.
- Maturity in the use of analytic tools.

Perform Crash Causation Research

The purpose of this research program is to develop an in-depth understanding of crash causation including the factors associated with driver behavior, traffic interactions and the environment (roadway) to support state and local highway/traffic safety programs.

Current Knowledge and Practice

Only a single multi-disciplinary accident investigation (MDAI) study, performed in the 1970s at Indiana University, has developed data giving insight into the role of human behavior and human factors in crash causation. While landmark research, it was performed in only one area of Indiana and has never been expanded or replicated.

Rationale

A major in-depth crash causation study, more representative of the variety of driving experiences on U.S. roadways, the changing nature of the traffic environment, such as increased traffic density, the diversity of drivers and vehicles and the changing sociology of driving, e.g., increased speed and aggressivity, is crucial to expand our understanding of why crashes occur. "Human error" offers virtually nothing about the actual behaviors leading to the crash. An understanding of the specific traffic scenario, roadway environment and driver behavior will give us insight on how to design countermeasures and programs in the driver, vehicle and roadway domains. This study would not only use MDAI crash investigation and reconstruction methods but would also utilize new sources of data, e.g. event data recording, to provide the needed insights.

Expected Result

• Increased understanding of the human role in crashes, i.e. how human behavior is impacted by highway design and operations as well as vehicle design and handling characteristics.

- Increased knowledge about how human decisions, responses and behaviors lead to crashes.
- The ability to tailor countermeasures to specific high-risk audiences.

We now know there are high-risk sub-groups in the driving population but we do not know enough about their driving behavior to develop or tailor countermeasures for them. In short these data are needed to develop the next generation of highway and traffic safety countermeasures and programs. A similar study was recently authorized by Congress to study motor carrier crashes.

POTENTIAL BENEFITS

The major purpose of research, development and implementation focus on safety management and data systems strategies is to develop and establish more effective, efficient and productive techniques and processes. Maintenance of these systems should become part of ongoing safety programs.

DRIVER COMPETENCY

BACKGROUND

There is a widely held belief that driver competency, i.e. the ability to drive in a proficient manner, is directly related to safety. More competent drivers have fewer crashes than those less competent. While simple enough in concept, the notion of competency is complex, subject to many interpretations and known to interact with many other factors to influence safety.

In the context of this strategic research plan, competency refers to a driver's ability to exhibit basic vehicle control skills and operating practices needed for the safe operation of a motor vehicle. In general, research suggests these two components of driver behavior are a factor in about half of all crashes. They appear to be much less prevalent in fatal crashes where high-risk behaviors of a more motivational character appear to dominate.

There is currently no overwhelming evidence that competent drivers have fewer crashes. Those crash reduction benefits that have been noted are of a size commensurate with other driver-oriented countermeasures. There is evidence that driver competency can be improved through education, licensing and post-license control systems. Research also suggests that competent drivers should be able to avoid some crashes that less competent drivers could not. Some estimates suggest one-third of all crashes could be avoided if drivers were capable of executing specific avoidance maneuvers.

In general, there are four subgroups within the driving population whose crash experience might be ameliorated by enhancing their competency to operate a motor vehicle in certain situations.

- Young drivers who lack the experience and proper judgment to make safe decisions particularly when new situations are encountered
- Older drivers who have lost certain visual and cognitive abilities that compromise their ability to operate safely
- 3. Experienced drivers who at one time or another degrade into a lower level of consciousness or attentiveness reducing their ability to safely operate the vehicle
- 4. Small diverse groups of drivers who unknowingly and unwittingly continue to make unsafe driving decisions simply because they have no knowledge of the unsafe actions they are taking

While it is difficult to estimate the magnitude of the problem or the benefits that could be attained through increasing competency among these groups, available evidence does suggest that lack of competency is a factor in a significant portion of all motor vehicle crashes. Because competency can be mediated by training and other approaches, it is reasonable to expect that efforts to increase driver competency should improve safety.

RESEARCH NEEDS

Solve the Problems of Novice Drivers

Novice drivers (those just beginning to drive) represent approximately 7 percent of the driving population, 14 percent of the crash population and about 20 percent of the fatal crash problem. The fact they are over represented in crashes is not surprising; it is simply one manifestation of a more general "Novice Effect," i.e., the propensity for novices in any endeavor to make mistakes.

Evidence suggests that much of what novices need to learn to drive safely can only be learned via the act of driving. While training would be expected to expedite this process, evidence as to the effectiveness of training novice drivers is very limited. Nonetheless, the major challenge to improving novice driver safety is to manage their "learning" how to drive. Research suggests that limiting novices operation of a motor vehicle to low risk environments during this initial learning phase and applying incentives that encourage them to drive safely are key to meeting this challenge.

The recent adoption of graduated driver licensing systems by many states is a significant step in the right direction, and emerging evidence suggests they are effective in achieving the goal of reducing novice driver crash experiences during the initial learning period. Even with these successes, however, there remains room for improvement. Careful analyses of these programs are needed to better understand what aspects of graduated licensing systems work. Efforts to develop effective training and licensing programs should also continue. Research is also needed to identify mechanisms for increasing restraint use among novices, which is still among the lowest of any age group.

Perhaps the greatest research need in this area of safety is a better understanding of the factors that underlie the crash experience of novice drivers. Those analyses of novice driver crashes that have been conducted suggest that the basic problem of novices is that they "look, but don't see." That is, they fail to correctly interpret the situation facing them with regard to the appropriate action they should take. Specific findings suggest that that novices are:

- Less able to estimate speed and distance of oncoming traffic in pulling out from stopped traffic or turning left across opposing traffic.
- 2. Unable to evaluate relative speeds, closing distances and braking characteristics when following other vehicles.

3. Unable to maintain control of the vehicle in some situations, e.g., head-on and run-off-theroad crashes.

By about age 20, these types of errors appear much less prevalent in the crash experience of drivers. The challenge of a research effort is to define mechanisms that more quickly improve a young driver's skill and ability to properly react to new situations at earlier ages.

Current State of Knowledge and Practice

The general crash characteristics of novices drivers is well understood, although little is known about the differences between "new" novices and those with one or two years of driving experience with respect to the specific aspects of their crashes. While graduated driver licensing systems are effective in reducing the crash experience of novice drivers, little is known as to how the mechanisms of these systems impact their crash experience. Of greatest need is a better understanding of the "errors" committed by novices that lead to their elevated crash experience.

Rationale

Without a good understanding of novice driver errors, it is impossible to develop training and licensing systems with good potential for improving safety. A significant growth in the number of novice drivers expected to enter the driving population in the next decade accentuates the importance of developing effective systems for managing their learning experience.

Expected Results

- A better understanding of the effects of specific provisions of graduated driver licensing systems.
- Explicit determination of major young driver crash characteristics for which they are overrepresented taking the impact of graduated licensing into account.
- Development and testing of relatively low cost driver improvement enhancements that can

substantially improve skills and control abilities of young drivers.

- Full-scale deployment and evaluation of pilot demonstration programs to more quickly improve young driver safety characteristics.
- Establishment of a delivery system that can be integrated into a state's safety programs.

Develop Countermeasures for Managing Inattention

Inattention has long been a factor in motor vehicle crashes. Studies of this aspect of driver behavior have consistently found that inattention is present in about half of all crashes. Regardless of its root cause, countermeasures that can assist drivers in managing inattention offer significant promise as a concept for reducing crash frequency and severity. A considerable number of crashes occur because drivers are not paying sufficient attention to the driving task. Fatigue, sleepiness, daydreaming, talking on a cell phone or to passengers and performing other in-vehicle tasks contribute to this overall degraded state. The key opportunities to reduce crashes associated with loss of alertness are as follows:

- Prevention through pre-trip actions to minimize the potential for loss of alertness.
- Recognition of entrance into a degraded state of attention. Individuals can accomplish this
 on their own or through external features, such as in-vehicle ITS technologies, rumble strips
 adjacent to the vehicle or helpful passengers.
- Potential enhancements to all highways (the infrastructure) that can alert drivers who become drowsy and deviate from the wheel path areas.
- Safe actions drivers should take once a degraded state is recognized.

Current State of Knowledge and Practice

There is a general understanding that inattention is a major factor in crashes and that it stems from many sources. Within the vehicle, there are numerous behaviors that contribute to
inattention and none seems to predominate. In spite of their growing popularity, there is little evidence that telematics devices pose a unique threat to driver inattention. Only the most rudimentary systems for monitoring driver alertness are in development and none has been demonstrated to reduce the frequency with which inattention contributes to crash involvement.

Rationale

The challenge of this research effort is to find more effective actions drivers can readily take before getting into the vehicle to substantially reduce the potential of drifting into a degraded state of driving. In addition, a continued research effort is needed to better help drivers recognize that they are beginning to have alertness problems either by in-vehicle or infrastructure enhancements. Finally, research is needed to help drivers, who recognize that they have slipped into a degraded state, minimize the potential for re-entering the degraded state while driving.

Expected Results

- An effective delivery system on pre-trip action drivers can take to minimize the potential for entering a degraded driving state.
- An effective in-vehicle warning system that alerts drivers entering a degraded state of attention.
- Enhanced pavement rumble strip concepts that can be applied on a majority of highways.
- Effective and acceptable mechanisms and strategies drivers can use to remain alert once degradation is recognized.

Enhance Safe Mobility for Older Drivers

Considerable research has been accomplished and is underway to improve the safe driving characteristics and continued safe mobility of older drivers. This is particularly important as the driving population ages and the need to retain self-mobility increases. Of possibly greatest

import is the anticipated growth in the number of older persons living independently but not driving. Satisfying their mobility requirements will impose new demands on the country's transportation system.

Current State of Knowledge and Practice

Much is known about the aging process that contributes to increased crash risk for older drivers. Much less is known about the effectiveness of countermeasures designed to address this increased risk. Available evidence further indicates that drivers are not at increased risk of crash involvement solely as a function of age until about age 75, and even then, individual differences predominate. Because the largest portion of older drivers are not at increased risk, it is not anticipated that efforts to identify older unsafe drivers or improve older driver safety will produce large gains in safety for the general driving population or for older drivers. All evidence points to a goal of insuring that the mobility of older drivers remains as safe as possible as opposed to limiting the mobility of older drivers to achieve safety goals.

Rationale

Research is needed to attain deeper insight into the relationship of the aging process to the increased crash characteristics of older drivers. Once these characteristics are adequately defined and understood, assessments of potential interventions including education, skill rebuilding, utilization of new in-vehicle technologies and options to reduce associated risk taking need to be defined and evaluated in terms of cost, probable crash impact, population coverage and impact. Promising outcomes need to be fully demonstrated and evaluated to ascertain cost, acceptability, effectiveness and ability to deploy in addition to defining other underlying issues associated with the strategy.

Expected Results

- A much deeper understanding of the crash characteristics of older drivers and the relationship between those characteristics and to reduced driving skills and abilities.
- A set of skill building education, in-vehicle technology assistance and other opportunities to substantially improve the safe driving characteristics and continued mobility of older drivers.
- A delivery system to effectively and widely deploy the demonstration.
- Enhanced opportunities to maintain quality mobility.

Create Learning Opportunities and Resources to Improve Driver Skills

A full one third of all fatalities do not involve alcohol, aggressive driving or lack of safety belt use. An even greater portion of all crashes lacks these contributory factors. In many of these crashes, drivers are unknowingly taking risks that place them at heightened risk of crash involvement. Examples include the following:

- Not recognizing and taking into consideration the fact that stopping distances are about twice as long on wet pavements as on dry pavements.
- Looking left then right but then not looking left again before pulling out from a stop sign, driveway, etc.
- Failing to take into consideration that turning left across two lanes of traffic takes much more time than crossing one lane of traffic and requires a much longer gap in opposing flow.

While a majority of drivers make the right decisions in given situations, some unknowingly make unsafe decisions or take unsafe actions when safer alternatives exist. Unfortunately, in many of these situations there are few, if any, explicit learning opportunities or resources available to make drivers more knowledgeable.

Current State of Knowledge and Practice

Almost nothing is known about the mistakes made by drivers that contribute to crash involvement. This is particularly true for those crashes that result from inadvertent driver errors. In fact, the universe of driver error is perhaps the least understand aspect of motor vehicle safety. Without this understanding it is impossible to develop or evaluate countermeasures to address this particular issue.

Rationale

Developing a thorough understanding of inadvertent driver error is critical to further improvements in motor vehicle safety because these errors are the predominate causal factor in motor vehicle crashes. The purpose of this research initiative is to identify the major, highly unsafe decisions small groups of drivers are making, determine corrective actions and develop effective mechanisms to communicate the right information so that drivers can recognize unsafe actions they may be taking.

Expected Results

- A comprehensive understanding of the major unsafe actions small groups of drivers make that strongly correlate with severe crash occurrence.
- Corrective techniques or guidance for drivers to eliminate the unsafe actions.
- Strategies and requirements to deploy the information so the targeted groups recognize they have a problem and take corrective actions to stop it.
- The overall thrust of this initiative is to upgrade the safe driving performance of all drivers.

POTENTIAL BENEFITS

This effort requires partnerships with diverse groups performing research in the same general area. The research organizations need to work collectively together to develop effective products

that can improve driver competency. Since driver competency issues can be associated with up to one third of all fatal crashes, modest gains in improving driver competency can produce significant improvements in highway safety.

HIGH-RISK DRIVERS

BACKGROUND

The driver's role in safe road transportation is well known. Numerous studies have documented the fact that driver behavior is the major contributory factor in motor vehicle crashes. Most estimates conclude that 85 percent of the factors contributing to crashes are in some way related to the behavior of the driver. Research has also demonstrated that driver behavior is the most difficult aspect of the transportation system to manage.

Purposeful risk taking by drivers is one element of driver behavior known to contribute significantly to crash involvement. Examples of such behaviors include driving under the influence of alcohol, operating at unsafe speeds, ignoring traffic control devices and failure to use restraints.

The factors that underlie these high-risk behaviors are complex and not well understood. While some research has been performed in this area, much additional insight is needed to thoroughly understand what motivates drivers to engage in these behaviors. Regardless of the specific reasons for their occurrence however, it is abundantly clear that meaningful progress in safety cannot be made without significantly reducing the number of drivers in the population who engage in these behaviors. In fact, any major gains in safety as reflected in the nation's fatal crash experience would require a significant change in the propensity for drivers to engage in high-risk driving acts, no matter how difficult the task.

RESEARCH NEEDS

Reduce Impaired Driving by Targeting Drivers with High Blood Alcohol Content

Alcohol-related fatalities remain one of the most significant concerns in highway safety. In 2000, according to the National Highway Traffic Safety Administration, the number of estimated fatalities in crashes with one or more drinking drivers and/or non-motorists (16,068) rose by 1.8% compared to 1999. Many obstacles to improvements in this statistic exist. Perhaps the greatest is the extent to which drivers with a high blood alcohol content (BAC) are involved in fatal crashes. The average BAC for impaired drivers involved in fatal crashes has remained well above legal limits throughout the entire history of national efforts to curb impaired driving. Further complicating progress is the fact that about 75 percent of all drivers arrested for impaired driving are "problem drinkers" in that they frequently consume at high levels. If we are to be successful in reducing the fatal crash rate by measurable amounts we must find ways to prevent these persons from driving.

Current Knowledge and Practice

Considerable research has and is being performed to better understand the problem and evaluate the effectiveness of existing and proposed legislative, educational and enforcement strategies to reduce drinking and driving. However, virtually all of these strategies are "general deterrents," i.e., they are directed toward all drivers, not just those who regularly consume alcohol to high BAC levels. This research indicates that many of these general deterrent countermeasures are effective at a level consistent with similar countermeasures directed at other high-risk driver behaviors.

Much less is known about their effectiveness in preventing impaired driving and very few countermeasures have been directed at "problem drinkers." Of these, ignition interlocks have

been found effective in preventing impaired driving only as long as they are on the vehicle.

Rationale

Significant gains in safety as a result of reducing the incidence of drinking and driving will depend on our ability to affect the frequency with which persons who consume to high BAC levels drive after drinking.

Expected Results

A better focused coordinated alcohol research effort that results in more important and effective research products

Increase Child and Adult Restraint Use

Restraint use continues to increase across the country and now stands at about 71 percent according to the Fall 2000 National Occupant Protection Use Survey. Rates are even higher for child restraint use. Nonetheless, use rates in the United States lag far behind many other countries and almost 18,000 unbelted people died in crashes in 2000. Considerable research has been produced and continues to increase belt use through legislative, educational and enforcement initiatives. It is important that this effort be continued, coordinated and intensified to find more effective ways to convince people to buckle-up. With respect to children, attention needs to be devoted to closing loopholes in existing restraint legislation that limits restraint use to children at very young ages and fails to require restraint use for rear seat occupants, many of whom are children. Approaches that have the potential to reap substantial increases in adult belt use rates need to be identified and prepared in formats that permit rapid national deployment.

A principal challenge is to increase restraint use among those drivers who are least likely to wear restraints and most likely to be involved in crashes. Even with the major gains that have been achieved in restraint use, the fatality rate remains at a higher level than would otherwise be expected because of the continued low belt use rate among this population. Existing evidence indicates that passage and enforcement of primary restraint use laws has little effect on the probability these occupants will use restraints.

Current Knowledge and Practice

Evidence clearly indicates that a combination of primary restraint use laws, aggressive enforcement and public information programs are key to getting the majority of the driving population to use restraints. Little is known about the effects of these countermeasures on those subgroups resistant to restraint use, other than the fact they don't work. Research has yet to be initiated that provides clues as to what types of countermeasures would affect the restraint use behavior of these occupants.

Rationale

This research is intended to reach the resistant groups. Until this group begins using restraints, fatality and injury rates will remain at levels higher than is indicated by research as to their effectiveness. Automatic occupant protection systems are not likely to provide a level of protection equal to that afforded by manual restraint systems; therefore, increases in restraint use by those groups most likely to be involved in fatal crashes is required if we are to see major improvements in safety.

Expected Results

• A better-focused, well-coordinated restraint use research initiative that produces and deploys innovative concepts to significantly increase belt use especially among the most resistant groups.

Enhance the Effectiveness of Automated Enforcement Equipment

Over the last 30 years, vehicle miles traveled has nearly tripled, the number of drivers has

increased by 70 percent and the number of vehicles has doubled. In this same period of time the number of police officers enforcing traffic regulations has remained relatively constant. The net result is that the probability of offending drivers being detected has declined dramatically. Research continues to demonstrate that the probability of detection and apprehension is a major factor in drivers' willingness to comply with traffic regulations.

Within the past few years, implementation of automated speed detection and red light running enforcement technologies have produced significant changes in the likelihood of drivers engaging in these high-risk behaviors and significant reductions in associated crashes. Emerging technological advances will allow progression beyond these environments to other high crash risk concerns such as tailgating, certain forms of reckless driving and impaired/fatigued driving. In each of these cases, it is fundamentally important that the vast majority of the traveling public accepts new enforcement tools as being in the public interest before, during and after deployment. Perhaps some warning that the systems are would only detect those drivers who consciously violate the warning would be acceptable to most drivers.

Current Knowledge and Practice

The effectiveness of current automated speed detection and red light running technology is known. Both their effects on driver behavior and crash propensity are known. Little is known about other emerging automated enforcement technologies. The major obstacles to wider use of these technologies are public acceptance and criteria for their use that are essential if they are to increase safety.

Rationale

This research effort will be used to identify, investigate and develop prototype systems that can substantially increase enforcement capabilities in major risk taking categories. In addition, it

will define the means by which it can be effectively deployed while maintaining public support.

Expected Results

 Various prototype automated enforcement tools in key risk taking areas associated with significant crash problems that can be readily transitioned into operational systems and dramatically increase the enforcement capabilities of police officers.

Prevent Unlicensed/Revoked Drivers from Driving

Annually, over 6,000 fatal crashes involve drivers with invalid or revoked licenses. Many states have tried various initiatives to keep suspended/revoked drivers from driving without much success. A recent study indicates that up to 25 percent of drivers involved in fatal crashes are unlicensed or improperly licensed at the time of their crash. Research also indicates that while most suspended/revoked drivers continue to drive, their risk of crash involvement while doing so is less than their counterparts with similar driving records but greater than the remainder of the driving population. Perhaps the most significant consequence of this growing problem is the message it sends about the need to drive safely to retain the driving privilege.

Current Knowledge and Practice

Existing knowledge is limited for understanding the frequency with which unlicensed/improperly licensed drivers continue to drive and their involvement in motor vehicle crashes. Current countermeasures are limited to those of a regulatory or judicial nature. Little is known as to the relative increase in risk of crash involvement imposed by this subgroup or the effectiveness of countermeasures designed to prevent this behavior. Available evidence does suggest that technological measures that prevent operation of motor vehicles by unlicensed drivers are probably the best approach among current options.

Rationale

Research to develop technologies that effectively prohibit unlicensed drivers from operating motor vehicles and to demonstrate the effectiveness of these technologies is required.

Expected Results

 Development and deployment of initiatives that effectively reduce driving by revoked/suspended drivers.

Curb Aggressive Driving

Though there have always been aggressive drivers, the incidence of aggressive driving resulting in crashes, injuries and deaths appears to be more prevalent in recent years. Uncontrolled anger, excessive speeding, changing lanes frequently without signaling, following too closely, driving on shoulders to pass, shouting or gesturing at other drivers and stress created by traffic congestion are among the causes and manifestations of aggressive driving. Over the past few years, there has been considerable discussion on a definition of aggressive driving. While yet to be defined, it is important that this dialogue continue and that a comprehensive definition be established that has the support of safety organizations. This would provide a starting point for systematically establishing coordinated research efforts, performance measures and strategies to impact the problem.

Current State of Knowledge and Practice

The basic facts concerning the degree to which aggressive driving is involved in crashes are known to the extent necessary to justify the formulation of countermeasures. Little, if anything, is known about the effectiveness of those few aggressive driving countermeasures that have been implemented. Some enforcement countermeasures have been developed, but none have been evaluated for their ability to impact the frequency with which drivers engage in these behaviors.

Rationale

This initiative requires integration with many others including automated enforcement, young drivers who apparently have a high degree of aggressive driving-related crashes and impaired drivers. The effort will search for innovative and effective solutions, test and evaluate the innovations and prepare the most promising techniques for national deployment.

Expected Results

• The identification of promising innovative solutions that, supported by research and evaluation, can be deployed nationally to reduce aggressive driving.

Attain a Deeper Understanding of Risk-Taking Characteristics

A more thorough understanding is fundamental to determining what strategies are effective in reducing the likelihood that drivers will engage in high-risk driving behavior. While some progress can be made without a well-founded knowledge of the motivators of this type of behavior, any substantial progress requires a more in-depth understanding than currently exists.

Current Knowledge and Practice

Little is known about the interpersonal factors that lead to high-risk driving behavior. Most of what is known is of a general nature and relates more to the frequency with which these behaviors are associated with crashes.

Rationale

The goals of this effort are to identify the major risk taking events drivers take that are associated with severe crashes, document the driver characteristics related to these behaviors and develop countermeasures which curb this behavior.

Expected Results

 A thorough mapping of the decision making process for risk taking among targeted driver groups, including individual variations, that will help define effective strategies for changing the perceived reward or loss side of the risk taking decision equation and reduce risk taking. In addition, the research effort will establish mechanisms to perform impact assessments of various strategies and insight on delivery systems.

POTENTIAL BENEFITS

This effort is both short and long term. It requires partnerships among all agencies performing research in high risk driving and groups who can impact aggressive driving by implementing the products that emanate from the research. Since risk taking is such a predominate factor in severe crashes, the identification of innovative solutions can have a profound impact on highway safety. Coupled with the prototype development will be mechanisms to deploy it effectively in a way that reduces risk taking and has the wide support of the traveling public.

LIGHT DUTY VEHICLE SAFETY

BACKGROUND

Drivers of racecars routinely survive catastrophic crashes on the racetrack. Similar crashes involving today's conventional light duty vehicles too frequently result in death. Enhanced levels of crash survival are possible with improvements in vehicle crashworthiness. Moreover, the vast majority of crashes that do occur are precipitated by driver error. And here too, improvements in vehicle design can assist a driver in compensating or recovering from these errors.

Thus, opportunities exist to improve occupant safety through vehicle enhancements in two major categories: 1) Vehicle improvements that enable the to driver recognize and possibly compensate for errors or inappropriate actions, and thus, reduce the frequency of crashes. (The DOT's intelligent vehicle initiative (IVI) is the primary effort in this area.) 2) Improving the crash survivability of vehicles to reduce the consequences of crashes when they do occur.

IVI is a multi-year effort currently funded at between \$25 and 30 million annually. Its primary focus is to accelerate the introduction of technology that can reduce crash frequency into the light duty vehicle fleet. In this area, IVI is pursuing research into measures designed to reduce the number of rear-end collisions, intersection collisions, collisions during lane changes and the number of roadway departures. To a lesser extent, IVI is also addressing potential problems that can result from the rapid introduction of in-vehicle telematics. The vehicle safety initiatives in this proposal assume that the IVI will continue and will provide some of the resources to pursue some of the strategies enumerated herein.

Unlike some of the other safety research initiatives discussed elsewhere in this document, all of the light duty vehicle safety initiatives will be significantly strengthened to the extent that they

involve a strong public/private partnership including the DOT and the world's motor vehicle manufacturers.

RESEARCH NEEDS

Enhance Crash Avoidance Capabilities through Improvements in Vehicle Handling and Stability, Braking and Traction Control, Conspicuity, Lighting and Signaling Increase Understanding of the Human/Machine Interface in Light Duty Vehicles

Current Knowledge & Practice

Current light duty motor vehicles provide a very high level of vehicle performance in almost every area. But we still continue to see that most crashes occur because of driver error. And the overall statistics suggest that the proportion of crashes attributable to driver error has not changed significantly over the last 25 years. Advances in vehicle electronics, vehicle sensors and vehicle-based computers can provide further improvements in fundamental vehicle attributes like braking, traction control, stability, etc. The challenge is whether we can provide improvements in vehicle technology that are designed in such a manner so that they produce meaningful improvements in driver skills and a concomitant reduction in crash frequency. That is why the two strategies of enhancing vehicle crash avoidance capabilities and increasing our understanding of the human/machine interface are listed together. While we know how to produce vehicles that can perform better, our understanding of how driver's actually make use of these enhancements has not kept up with our advancing technology.

Rationale

The rapid advances in vehicle sensing technology and vehicle electronics have the motor vehicle on the verge of entering a drive by wire era where significant enhancements in vehicle performance will be available. The challenge before the research community is to increase our understanding of the manner in which drivers actually perform the driving task so that improvements in collision avoidance technology actually produce meaningful reductions in the frequency of on road collisions. Improvements in braking, handling and stability, traction, lighting and signaling must reflect the enormous variation in driving skills and abilities that exist in the 150 million drivers licensed to operate vehicles on America's highways. This means that we need to develop a much better understanding of the driving task and of the way that the full range of drivers responds to changing vehicle technology. Only then can we be certain that improvements in vehicle technology produce improvements in motor vehicle safety.

Expected Results

- A comprehensive set of vehicle enhancements that can improve vehicle handling and stability, traction control and braking, and lighting and signaling for incorporation into the new vehicle fleet.
- Assessment of the driving task and the development of human factors evaluation protocols that can be used to integrate these improved crash avoidance technologies into future vehicles.

Enhance the Crash Survivability of Vehicles through Improvements in Restraint System Designs and Passenger Compartment Integrity

Increase the Understanding of Vehicle Compatibility in Motor Vehicle Safety

Develop Improved Biomechanics Evaluation Protocols and Crash Dummies

Current Knowledge & Practice

Over the last 30 years, the likelihood of an occupant surviving a serious crash has improved dramatically. The death rate per hundred million miles traveled has dropped from 5.6 to 1.6. This reduction can be associated with both improvements in highways, vehicle crashworthiness

and restraint system technology. Currently, airbags used in conjunction with lap/shoulder belts can reduce the risk of fatalities by 50 percent. However, it is not likely that further improvements in restraint technology by themselves can increase the likelihood of crash survivability without further improvements in the structural integrity of light duty vehicles. Moreover, the changing mix of light duty vehicles on the road, while a reflection of consumer demand, also presents challenges to safety researchers, as vehicle-highway safety hardware mismatches are responsible for an increasing number of highway casualties. And finally, while it is possible to develop improvements in the way that vehicles are designed, if these changes are to result in casualty reductions, it is critical that our understanding of human biomechanical tolerances to crash related impacts be better understood. The growing understanding of human injury tolerance combined with the growing use of advanced modeling techniques relying on finite element modeling suggests that we are on the threshold of significant improvements in crash survivability.

Rationale

The ability to make changes in motor vehicles is always with us. The question that requires enhanced understanding is how these changes can produce a reduction in the casualties that result from crashes. The goal of this strategy is to reduce the number of injuries and fatalities produced in crashes through improvements in vehicle integrity and changes in vehicle design to more efficiently manage the crash energy produced when vehicles of different size and stiffness crash. In addition, improvements in restraint systems that are tailored to these future vehicles should also increase the probability of crash survival. And finally, if we are to assure that these changes really do enhance vehicle safety, we must expand our understanding of human injury tolerance, and more importantly, develop biomechanical tools to better evaluate engineering changes.

Expected Results

- Increased understanding of the way that vehicles of different sizes and stiffness interact in crashes in order to develop effective countermeasures.
- Improvements in vehicle structural integrity, including the ability to better survive rollovers and provide survival space in a larger range of crashes.
- Improvements in occupant restraint systems. This should at a minimum include the development and increased use of seatbelts that are integrated into seating systems and that are routinely equipped with pretensioners and load limiters. And of course, the next generation of improved frontal airbags and the rapid introduction of side impact airbags, all designed to take advantage of our increasing ability to provide occupant sensing systems holds promise for further crash casualty reduction.
 - Development of enhanced evaluation tools. These include improvements in finite element modeling and its application to fleet safety analyses for use in vehicle compatibility research. Probably more critical is a better understanding of human injury tolerance for soft tissue injuries and for injuries that occur in other than frontal impacts. Here we require additional research on injury tolerance and the development of improved simulation models and crash test dummies.

Improve Driver Fitness Monitoring Technology and Apply It to the Future Vehicle Fleet *Current Knowledge & Practice*

Even with the significant reduction in the number of fatalities attributable to impaired driving, this still remains one of the largest highway safety problems. And, although the impact of alcohol on the degradation of driving skill is understood to the point where we can specify BAC levels that can be used in impaired driving laws, the practice of monitoring BAC levels through in-vehicle systems is used only for repeat DWI offenders. There is also a growing understanding of the impact that sleep deprivation can have on the reduction of driving skills, although the ability to specify how this is measured is only now beginning to be recognized. And finally, there are areas that are just not understood at all, such as the risk-taking behavior of different drivers or the ability to predict the onset of aggressive driving.

Rationale

This initiative is aimed at using in-vehicle sensing technology to recognize impaired driving. This might be accomplished in a variety of ways. The growing number of vehicle monitoring sensors that will be incorporated in future collision avoidance systems might be developed to the point where they can detect erratic driving patterns associated with impaired driving regardless of the source of the impairment. It also might be possible to develop systems that monitor eye movement to determine when a driver is too tired to continue driving safely.

Expected Results

- The ability to specify driver fitness so that it is possible to differentiate an unsafe driver from a safe driver.
- Technology to measure these levels in a vehicle.
- Interventions that could range from a mild warning to a driver to situations where the vehicle is shut down.

Improve the Safety of Children in Vehicles

Current Knowledge & Practice

Over the last three decades, there has been a growing recognition that children are not merely small adults. They suffer different types of crash injuries and require unique types of occupant

restraint systems. Over the last two decades, the use of child restraints in the U.S. has increased from negligible levels to more than 80 percent, accompanied by a reduction in child occupant injuries and fatalities. But as we have made significant improvements in the safety of the smallest passengers, toddlers and older children have not fared as well. The use of appropriate child restraints declines with each year of age, and virtually no children in America travel in booster seats. In addition, when children are in child seats, it is rare that the restraint is properly installed in a vehicle or that the child is correctly seated in the restraint. And finally, while child restraints work well in crashes, they clearly can be improved to perform better in other than frontal crashes.

Rationale

While there have been significant improvements in child safety, given the value that our society places on its children, further improvements are required. One class of improvements is needed to upgrade the existing child restraint safety standards to cover children at least through age 10 and other than frontal crashes. In addition, we need to monitor the performance of advanced frontal airbags and second-generation side airbags to make certain that children are not placed at unreasonable risk.

Expected Results

- FMVSS 213 needs to be updated to reflect 21st century vehicles. It is currently based on a bench seat from a mid-1970s vehicle.
- Development of a 10-year-old dummy to evaluate booster seats, to replace the current dummies used in that standard with more modern dummies, and to apply upgraded injury criteria to those child dummies.
- An upgraded standard to cover at least side impacts and possibly other collision modes as

well.

 Evaluation of advanced frontal airbag and future side impact airbag performance using more advanced child dummies.

Monitor the Performance of Vehicles in the Field through Data Analysis and Crash Investigations

Current Knowledge & Practice

The federal government does a better job of monitoring traffic safety than it does in almost any other field of public health. The NHTSA collects uniform data on all fatal crashes and on a large enough volume of tow away crashes so that it can make a reasonably accurate assessment of the performance of the vehicle fleet. However, special studies are missing that can be used to evaluate problems that can be anticipated but that cannot currently be evaluated using the existing data systems. (This subject is so important to vehicle safety research that it is included here, even though it might duplicate efforts included under the Safety Management and Data Systems strategies.)

Rationale

Under this strategy, the government would be charged with developing a continuing series of specialized traffic safety studies to evaluate problems or issues that cannot be evaluated on a timely basis. For example, specialized studies are needed to monitor safety issues associated with specialized populations, such as the elderly or the very young. Special studies are also required to evaluate changing technology, such as the performance of advanced airbags or the impact that in-vehicle telematics will have on motor vehicle safety.

Expected Results

• The capacity to conduct specialized studies to address problems that can reasonably be

anticipated or to assess the application of new technology on the safety of the vehicle fleet.

POTENTIAL BENEFITS

These strategies reflect a long-term research initiative. Because they impact the underlying technology of the entire vehicle fleet, they can have a very major influence on traffic safety. The long-term benefits can be profound in terms of preventing future loss of life; however, for it to really be effective, it needs to be pursued in partnership with the motor vehicle manufacturers and suppliers.

HIGHWAY INFRASTRUCTURE AND OPERATIONS

BACKGROUND

One-third of all motor vehicle fatalities occurs when a vehicle leaves the road. Almost one-fourth of all vehicle fatalities happen at intersections and the number of work zone deaths remains a high profile concern. The highway infrastructure is a contributor to the number and severity of crashes – as much as 15-20 percent of all crashes and highway fatalities. Even though more than 80 percent are attributable to driver error, behavioral programs alone cannot resolve all of them. In some cases, infrastructure improvements can compensate for driver behavior-related crashes. As seen on the Interstate system, the infrastructure can produce remarkably better safety results. We need additional knowledge and insight, gained principally through research, to identify and implement more effective roadside, intersection and work zone improvements. Gaps also exist in how car, truck and other highway users respond to different roadway configurations, especially intersections, and in knowing what types of safety countermeasures (Infrastructure and ITS) are effective for various hazard locations especially at night. In addition, many key safety research findings are not being implemented particularly at the local level because of unawareness. FHWA and State research and development efforts have proven successful. However, the easier activities have been identified. New methods and countermeasure are needed given current driving characteristics, traffic volumes and vehicle fleet changes.

Today's highways are vastly superior to those of the early or mid-1900s largely because of the continuous improvements in design and operations. However, the highway infrastructure is facing a major challenge. We now must learn how to operate the roadways as a system. We have design and safety guidelines, like the AASHTO geometric design policy, and they have served us well. However, traffic demands in the next 15-20 years are expected to be much greater and many of today's approaches will not provide the level of service expected by the users. We have developed technology to make roads and intersections operate more efficiently and safely than ever before, but often our state-of-the-practice is not in keeping with our state-ofknowledge. We must determine how to integrate driver and other user needs and constraints directly into the design solutions to make the road system operate more efficiently and safer given a continuous, annual increase in expected traffic flow. We still do not know how to properly mix and utilize new technology in our intersections, roadway, work zones and roadside safety systems. This is our safety challenge.

RESEARCH NEEDS

Develop a Comprehensive Set of Human Factor Safety Guidelines That Can Be Incorporated into the Design, Operation and Maintenance of Highways

This effort will define human factors safety guidelines related to infrastructure design and implementation that will make the highways safer for drivers. In addition to defining human factors safety guidelines, those infrastructure improvements that can enhance a driver's safety capabilities will also be defined along with their impact on the highway system. The effort will include compiling existing research findings, performing research in areas with critical gaps, pilot testing key findings and delivering the results to state and local officials in a format that they can readily incorporate into their designs, computer simulation models and operational processes. The results of this strategy will also provide the basis for a large portion of other infrastructure-based safety strategies.

Current Knowledge and Practice

Highway users are decision-makers and their decisions are based on the orderly processing of information about vehicles operating on the roadway. When road users expectancy is violated they become confused, may make erratic decisions, create unexpected conflicts, confusion and/or delay in the traffic stream and increase the risk to others. While substantial research is available on user needs, it has not been synthesized into a readily, useable format for highway designers. Standards and manuals for road design and traffic control are available, but they do not address the hierarchical user rules, needs and constraints. Engineers and human factor professionals have found, as in the recently completed Older Driver Highway Design Handbook, that when driver-centered research results are presented in an easily understood form the guidance is more often sought, accepted, and applied to solve design and operational problems.

TRB has already formed a Joint Subcommittee tasked with developing a Human Factors Safety Guideline for Road Systems. This effort, which also is joined by various non-US countries, is being developed to supplement existing documents like the AASHTO Highway Design Guide and the Manual on Uniform Traffic Control Devices. The Human Factors Guide for Road Systems will aid traffic engineers and highway designers with knowledge and information about driver needs that have been too often overlooked in highway design and operations

Rationale

No comprehensive human factor safety guidelines exist to aid highway designers and traffic engineers on what user needs are fundamental to highway safety.

Expected Results

• A comprehensive set of human factors characteristics and guidelines that are sufficiently tested to help designers, traffic engineers and maintenance managers incorporate the new

concepts into their work functions. This includes a comprehensive set of guidance principals for the application of enhanced pavement marking, delineation, signing and pavement and shoulder rumble strips to improve the driver's ability to stay in their lanes and on the road, particularly on lower volume rural roads.

 Design and operational guidelines, including graphics and descriptions, for trained state and local designers, traffic engineers and maintenance managers who are proficient in their use.

Perform Research to More Effectively Reduce the Consequences of Leaving the Road

In addition to keeping vehicles on the road, it is important that better methods be identified to minimize the severity of crashes once a vehicle leaves the roadway. This effort will develop cost effective safety products in areas where there are major gaps, increase the safety performance of existing appurtenances, reduce the potential for roadside rollover particularly involving SUVs and provide better guidance for highway designers. Analysis tools are needed to assist decision makers in all phases of highway planning, design, construction, operations and maintenance on the benefits, costs and cost-effectiveness of various products for use at different locations or road configurations.

Current Knowledge and Practice

Roadway design, particularly for highways built to Interstate standards, significantly reduces the frequency and consequences of vehicles leaving the road. Research has shown that visibility, roadway geometrics, signage, delineation and pavement markings all contribute to increased driver expectancy and retention of the vehicle on the roadway. Shoulder rumble strips are low-cost and extremely effective in warning drivers of imminent roadway departure so corrective action may be taken. Clear zones, break away poles, crash cushions, barriers and other forgiving devices are effective methods to reduce the crash severity of a vehicle that departs the roadway,

while gradual side slopes along the roadway reduce the risk of vehicle roll over.

Rationale

Nearly one third of fatalities resulting from motor vehicle crashes are the result of vehicles leaving the road. Effective treatments have been found and eliminated for many roadside hazards on high-speed roads, but not for other road classes. Roadside hardware does not perform uniformly for all vehicle speeds. This factor necessitates the undertaking of additional research if all roads are to be protected from the consequences of leaving the road.

Expected Results

- Effective low cost attenuating devices that provide protection for fixed objects such as trees, lights and utility poles that cannot be easily removed.
- Enhanced safety hardware for protecting a majority of vehicles based upon well-known crash conditions.
- An integrated effort among transportation officials, the automotive industry and the highway safety community to produce better roadside slope designs, improve vehicle stability, especially in SUVs and more skilled drivers who can prevent rollovers from occurring.
- Guidance for designers on safer urban roadside and street-scape design.
- Software systems with a set of analytical tools for screening the highway network to identify
 potentially hazardous run-off-the-road locations and suggest countermeasures to reduce the
 frequency and severity of car and truck accidents.
- Design and operational guidelines, including graphics and descriptions, for trained state and local designers, traffic engineers and maintenance managers who are proficient in their use.

Improve Intersection Safety

Poor driver decision-making, coupled with infrastructure features makes intersection negotiation

a difficult and often hazardous task. Car and truck drivers must make numerous and rapid mental calculations and estimations at controlled and uncontrolled intersections when assessing oncoming vehicle speeds, closure distances to the intersection, time to clear occupied throughlanes and the presence of pedestrians. Road users reactions are not uniform and they vary by age and experience. Unfortunately, crashes occur when drivers miscalculate or simply miss seeing a vehicle, pedestrian or bicyclist. This research initiative is an integrative effort to better define those driver requirements needed to safely negotiate an intersection, infrastructure improvements to enhance safe passage and enhancements to driver skills for improving intersection safety.

Current Knowledge and Practice

Much has been done to improve safety at the most critical point of the highway—the intersection. Traffic control devices, e.g., stop, yield, and advanced warning signs and traffic signals, increased sight distances, left turn lanes and traffic flow configuration help reduce the number of vehicle conflict points and improve safety. For some situations, system or network approaches, such as creation of a series of one-way streets can significantly reduce conflict points. More recently in the United States, roundabouts have been found to reduce the number and severity of intersection crashes by up to 50 percent in comparison to traditional stop or traffic signal controlled intersections.

Rationale

About 50 percent of all fatalities occur at intersections. Furthermore, about half of all crashes involving the older driver occur at intersections (twice the rate of other drivers). With the aging population, states and localities need to examine and modify intersections to respond to this potentially significant negative highway safety trend.

Every year more intersections are either built or modified, which increases the user exposure

to this road hazard. Intersection improvements offer a significant opportunity to reduce delays as well as fatalities, injuries and property damage crashes. To achieve overall national improvements in highway safety, intersection safety must be addressed.

Expected Results

- A comprehensive set of driver empirical and laboratory cognitive and situation-decision criteria for driver performance characteristics associated with all intersection crashes.
- Guidelines for the application and design of innovative infrastructure configurations and treatments at both signalized and un-signalized intersections.
- A set of innovative intersection collision avoidance systems applicable to both signalized and un-signalized intersections that complements infrastructure enhancements.
- Red light running identification and notification systems.
- Training strategies and programs to increase driver skills for intersection negotiation.
- The development and refinement of acceptable access management policies like road safety audits that reduce the likelihood of intersection-related crashes.
- Simulation techniques and tools to assess the safety and operational implications of alternative intersection configurations.
- Guidelines, including graphics and descriptions, for trained state and local designers, traffic engineers and maintenance managers who are proficient in their use.

Continue the Intelligent Infrastructure Initiative

An intelligent vehicle initiative is underway and is expected to create substantially safer vehicle travel in the future. Unfortunately, it may be 20-25 years before a significant amount of this new technology is incorporated in the bulk of the vehicle fleet. In the meantime, new technology can be added to the infrastructure that will make roads safer for all road users. The technology can

communicate information that will warn users of imminent problems such as potential vehicle-to vehicle conflicts, traveling too fast for roadway conditions, information about route conditions such as delays, work zones, and weather and emergency re-routing. These technologies when applied make the infrastructure "smarter" and give drivers sufficient additional information to negotiate a highway section or traffic condition safely. Cooperative infrastructure technologies will improve the performance and speed the implementation of future IVI systems and provide earlier opportunities to enhance road user safety by providing critical information directly to drivers in their vehicles.

Current Knowledge and Practice

Some of these new technologies have been tested and are available. Examples include:

- Smart curve warning signs to alert drivers who are approaching a curve to fast for the ambient conditions.
- Impending rollover detection and notification systems for truck drivers primarily on ramps and sharp curves.
- Fog and adverse weather detection and driver notification systems.
- Bridge ice detection and driver notification systems.
- Intersection collision warning systems to advise drivers of impending conflicts.
- Increased hydroplaning potential identification and notification systems.
- Deployment of lane and roadway markings that can be recognized by intelligent vehicle sensors.
- Enforcement systems, like red-light-running cameras, applied to sections of highway with a history of aggressive driving or truck/car crashes.

Rationale

While traditional methods of modifying roadways, roadsides and intersections to enhance road safety is the first choice, they alone should not be expected to carry the entire burden. Traffic and environmental conditions are dynamic and new technology is available that works well with continuously changing conditions. Smart technologies that work to supplement fixed infrastructure improvements will further enhance road safety. The development and implementation of this technology is necessary to eliminate highway crashes

Expected Results

- An effort to identify, enhance, test, pilot, deploy and establish wide scale deployment of reliable and effective intelligent infrastructure improvements at problem locations.
- Guidelines, including graphics and descriptions, for trained state and local designers, traffic engineers and maintenance managers who are proficient in their use.

Improve Safety in Work Zones

Highway work zones continue to create a major safety concern for motorists and between 750 and 800 people die annually in work zones. There is a need to increase the safety of work zones for drivers and workers alike especially at night. Also, a better definition of work zone crash characteristics and countermeasures is needed. While conditions have improved, it is necessary to find methods for improving work zone safety. It would also be beneficial from a safety perspective to use better, longer lasting materials and designs to lengthen the time between major work zone projects.

Current Knowledge and Practice

In response to the ISTEA of 1991 and National Highway Designation Act of 1995, the FHWA, in cooperation with the states and the private sector, developed and implemented a work zone

improvement program. The Strategic Highway Research Program also contributed to work zone operational and equipment improvements. Information regarding the many safety enhancements of these and other work zone safety programs is found in a Work Zone Safety Information Clearinghouse (www.wzsafety.tamu.edu). As of September 2000, the Clearinghouse database contained 262 descriptions of best practices to improve work zone safety. The site also contains information on equipment, outreach campaigns, standards and practices and training.

Rationale

TEA 21 has greatly increased the funds to relieve congestion due to growing traffic demands. Traffic management and control is too often neglected and varied which results in injury to both highway workers and road users. Smart technologies and approaches are required to provide work zone safety and customer satisfaction; otherwise work zone fatalities and injuries will continue.

Expected Results

- A better understanding of work zone crash and fatality characteristics.
- Work zone technology innovations that reduce road customer exposure and/or crash likelihood.
- Simulation techniques/tools to assess the implications of alternative configurations.
- Guidelines for alternative work zone configurations, operations and enforcement strategies.
- Design and operational guidelines, including graphics and descriptions, for trained state and local designers, traffic engineers and maintenance managers who are proficient in their use.
- Guidelines for designing highway projects to minimize safety costs from crashes.

Develop the Highway Safety Manual – A Tool for Automating the Inclusion of Safety in Highway Design and Operation

While "safety" has been a key emphasis of highway design and operation for decades, the best, most current safety practices have not been systematically examined during design. Engineers design by guidelines (e.g., the AASHTO Design Guide), and thus safety is included in the design to the extent it is in the guidelines. However, while the engineer examines potential tradeoffs in factors related to the environment, esthetics, costs related to earth moving, and other factors in the examination of alternative designs for a project, he/she does not systematically examine the tradeoffs related to deaths, injuries and crashes. In effect, the only "safety engineering" that is done is that built into design standards.

Current Knowledge and Practice

There is a significant body of safety knowledge that is not in a form that insures its use by individual highway and traffic engineers in their work. In addition, there are gaps in our knowledge of the effects of certain design parameters on safety at intersections, interchanges, non-junction roadway segments, and roadsides. Most design work is now done using Computer Aided Design (CAD) technology that allows the engineer designer to automatically conduct examinations of many different alternative designs for a given project. Unfortunately as noted above, CAD systems do not produce the output the engineer needs to make safety decisions – predictions of future crash levels based on inputted design parameters and expected traffic flow. FHWA initiated work to address this shortcoming in the development of the Interactive Highway Safety Design Model (IHSDM). IHSDM is a computerized module that will be added to existing CAD packages to output such safety estimates. Currently, this model only provides safety predictions for two-lane rural roadways.

Rationale

There is are both significant gaps in research knowledge and in the user-friendly "packaging" of existing research knowledge which has resulted in little true "safety engineering" in today's highway design practices. This need has been identified by TRB. In response, a consortium of TRB committees has established a special task group whose goal is to overcome this need through the development of a "Highway Safety Manual," a document and set of procedures which, similar to the Highway Capacity Manual, will allow the highway and traffic engineer to explicitly consider safety consequences in their work on a daily basis. The IHSDM will be a key tool in this Manual, but only currently concerns two-lane rural roads. There is a significant need for funding to both conduct needed research to fill in the knowledge "gaps" for other road classes and to extract and then to package existing safety knowledge in the Manual and it's related tools.

Expected Results

- New research results targets to gaps in existing knowledge of highway design and operation.
- The scientific extraction and "weighting" of results from existing research studies in order to combine them into sound, usable knowledge about design and operation.
- The development of user-friendly tools such as "Accident Modification Factors" which can be used in preliminary assessments of safety treatments.
- The development of methods and tools for combining new and existing knowledge into a set of safety predictors which can be computerized and packaged as an integral part of current CAD systems.
- Finally, when completed, this effort can result in the "automatic" inclusion of safety analyses in all design and operations decisions made by engineers.

POTENTIAL BENEFITS

Research has indicated that highway infrastructure play a contributing role in approximately 15-20 percent of all crashes. The global dispersion of relatively low-cost, effective highway safety improvements generated from new research can have a significant impact on overall crash statistics.
VULNERABLE ROAD USERS

BACKGROUND

Pedestrian, bicycle, and motorcycle fatalities account for approximately 20 percent of all highway traffic deaths. Pedestrians encompass a wide range of users, including people with disabilities. Other vulnerable road users include skaters and electric bicyclists. In the 2000 early assessment, 4,727 pedestrians, 738 bicyclists, and 2,680 motorcyclists died in motor vehicle crashes. In addition, a total of approximately 193,000 pedestrians, bicyclists and motorcyclists were injured. These numbers represent only those crashes that are reported to the police. Also many crashes occur in which the injury is not severe enough to result in a police crash report, does not occur within the public right of way or does not involve a motor vehicle.

The provision of appropriate facilities for pedestrians and bicyclists is crucial for reducing the number of injuries and fatalities. Not providing facilities for pedestrians and bicyclists has resulted in lost lives and injuries and in a reduction of walking and bicycling trips. The exact extent of the reduction in trips is unknown due to the lack of exposure data for these modes of transportation.

Facilities for walking and bicycling can be broadly categorized as being on-road and offroad. On-road facilities include bicycle lanes, wide outside curb lanes and paved shoulders. Offroad facilities consist of sidewalks, shared use paths and other types of trails. Improvements to facilities for pedestrians and bicyclists crossing roadways are an area of particular concern. Both intersection and mid-block crossings have been shown to be hazardous for non-motorized road users. The current design of these crossing locations can often result in conflicts between motorists and non-motorized users. Current knowledge regarding the safety effectiveness of particular engineering improvements to pedestrian and bicycle facilities is limited and requires further research.

Motorcyclists are highly vulnerable in the traffic stream largely because of their limited size. Motorcycle operators and passengers are often injured or killed when other vehicles turn into their path or overtake them from behind. Infrastructure design elements can be hazardous to motorcyclists, such as road bumps and humps, bridge and drainage grates, guardrails and fixed objects. The cause of motorcycle crashes, especially as they relate to the infrastructure, is inadequate and better knowledge is required before substantial reduction in motorcycle crashes can be realized.

Supplementary education for all system users will increase the effectiveness of pedestrian and bicycle facilities. Drivers need to be more aware of vulnerable road users and their capabilities. Similarly, pedestrians and bicyclists need to recognize the operational characteristics of motorists. All road users should be educated about the legal and operational requirements of the transportation system and its components. Educational materials to supplement engineering improvements are required to explain how these improvements are intended to function.

Transportation professionals are beginning to recognize that the safety and use of walking and bicycling as modes of transportation are important issues. Design guidance for pedestrian and bicycle facilities does exist, but it has not been widely accepted or incorporated into current practice. Quite commonly, facilities for vulnerable road users are an afterthought or are provided as a retrofit. Though some guidance exists, little is known about the safety effectiveness of various facilities and countermeasures or when these are warranted. The challenge will be to insure that pedestrians and bicycles are included in the routine planning, design and operation of our transportation system.

RESEARCH NEEDS

Improve Crash and Use Data Regarding Walking, Bicycling and Motorcycling

This effort will develop measures of exposure for safety and usage. Developing a measure of exposure for safety will help identify problem areas and allow practitioners to focus their limited resources on these areas. Use data can be used to normalize available safety information to provide a more realistic picture of the relative safety hazards for vulnerable road users. This effort will determine the most meaningful, relevant measures of use for motorcycles, bicycles and walking. The effort will include compiling existing research findings, relating relative pedestrian-rules-of-the-road, developing cost effective methodologies to collect the data, performing research testing these methodologies and delivering the results to state and local officials in a format that they can readily utilize.

Current Knowledge and Practice

Crash data regarding pedestrian-, motorcyclist- and bicycle-motor vehicle crashes are available from police crash reports. These data are mostly limited to crashes with motor vehicle crashes on public rights of way. These data typically do not include pedestrian-only, bicycle-only, pedestrian-bicycle crashes or crashes that occur off the roadway, i.e., parking lots, shared use paths, or sidewalks. Nationally, there are no sage data for walking or bicycling. A handful of local communities collect pedestrian or bicycle volume counts on a regular basis. Other communities collect pedestrian or bicycle data on a project-by-project basis.

Rationale

Currently, there is no standard methodology to collect these data. Without this information it is difficult to measure the effectiveness of countermeasures and to track changes in the amount of use.

Expected Results

- Pedestrian and bicycle crash rates for on- and off-road facilities that can be used to prioritize safety improvements.
- A measure of the actual amount of walking and bicycling to provide a baseline of current use and project future use.
- Methodologies for state and local transportation officials to collect walking and bicycling use data in a standardized format so that the data can be aggregated across jurisdictional boundaries.

Develop Accommodations to Allow Safer Road Sharing for Pedestrians and Bicyclists

It is crucial that provisions are made for large motor vehicles to safely share the road with smaller road users like pedestrians and bicyclists at intersection, at mid-block locations, and along roads and streets. The feasibility of using ITS technologies to enhance typical nonmotorists safety at crossings and other locations should be investigated. The effort will include compiling existing research findings, performing research in areas with critical gaps, developing design guidelines and delivering the results to state and local officials in a format that they can readily incorporate into their design and operational processes.

Current Knowledge and Practice

Design guidance regarding bicycle facilities is provided by AASHTO's1999 *Guide for the Development of Bicycle Facilities*. Similar guidance for pedestrian facilities is being developed under NCHRP 15-20. A small number of states such as Florida and Oregon do include pedestrian and bicycle provisions in their State highway design manuals. Overall, there is little guidance regarding the safety effectiveness of the various facilities and countermeasures. FHWA is completing a Pedestrian Safety User's Guide that will provide some recommendations regarding crosswalks, sidewalks and other countermeasures. There are legal requirements under ADA to provide access for people with disabilities but scarce information on the actual implementation. The U.S. Access Board is currently developing guidance on how to meet the ADA requirements.

Rationale

Most existing roadway designs do not provide for use by bicycles and pedestrians, though these groups desire and are legally permitted to use these facilities. Effective designs are critical for safety. The inclusion of pedestrian and bicycle facilities is more effective as part of initial project planning and design than when incorporating accommodations as retrofits.

Expected Results

- Improved design guidance, including graphics and descriptions, for crossings, mid-blocks and other road and street locations to be incorporated in state and local design manuals.
- Reduced user conflicts between motorists and non-motorists.
- Increased safety and operational efficiency of intersections for all users.
- Trained state and local designers, traffic engineers and planners who are proficient in the use of recommended design practice.

Develop Methodologies to Evaluate the Safety and Operational Effectiveness of Off-road Facilities Designed for Pedestrians and Bicyclists.

Design guidance is provided for off-road facilities, but only basic tools exist to evaluate the safety and operational performance of these facilities. This effort will build upon available information, collect needed data and develop improved methodologies for examining various design alternative and operational alternatives. It will investigate both intersections and non-intersection segments and should take into account the variety of facility users. The potential for

motor vehicle free zones as a safety countermeasure will also be investigated. The results will be delivered to state and local transportation practitioners in a format that they can readily incorporate into design and operational processes.

Current Knowledge and Practice

In the U.S., there currently is no methodology widely used to evaluate the safety and operational effectiveness of off-road facilities designed for pedestrians and bicyclists. The HCM 2000 will include a method to examine the operational effectiveness of such facilities in terms of user conflict, but this methodology has not been validated in the U.S. Information on user characteristics exists for pedestrians and bicyclists but not for other types of non-motorized transportation such as in-line skates or scooters.

Rationale

An increasing number of off-road facilities is being provided for pedestrians and bicyclists; however, reliable and standardized methods to measure safety and operational performance do not exist currently.

- Reduced conflicts between off-road facility users.
- Reduced conflicts between motorists and non-motorists at the crossing locations of these offroad facilities with roadways.
- Increased safety and operational efficiency of pedestrian and bicycle facilities.
- Trained state and local designers, traffic engineers and planners who are proficient in the use of recommended design practice.

Increased Visibility and Conspicuity of Vulnerable Road Users

The majority of pedestrian, bicycle and motorcycle fatalities occur between dusk and dawn when ambient light conditions are low. This effort will continue to explore and expand methods to increase the visibility and conspicuity of pedestrians and bicyclists. These will include vehicle technologies, such as ultraviolet (UV) headlamps and infrared night vision (IR), as well as improvements to the infrastructure such as UV lighting at crossing locations. The results will be delivered to state and local transportation practitioners in a format that they can readily incorporate into design and operational processes. The results will also be shared with vehicle manufacturers so that they will consider including these improvements in their vehicles.

Current Knowledge and Practice

Pedestrian, bicycle and motorcycle nighttime visibility and conspicuity rely primarily on conventional motor vehicle and street lighting. Retro reflective and fluorescent materials have been demonstrated effective is increasing the conspicuity of vulnerable road users. However, at present, usage of these materials is seen primarily on apparel used for construction and maintenance.

Rationale

Most pedestrian- and bicycle-motor vehicle related fatalities occur between dusk and dawn when ambient light conditions are low. Drivers, bicyclists and pedestrians overestimate their ability to see or be seen at night.

- Increased visibility and conspicuity of pedestrians, bicyclists and other road users including motorcycles.
- Reduction in nighttime pedestrian and bicycle and other road user fatalities and injuries.

Develop Educational Materials

All road users should be educated regarding the legal and operational requirements of the transportation system and its components, as well as enforcement activities to support traffic control of pedestrian and bicyclists. Educational materials to supplement engineering improvements are required to explain how these improvements should function and how enforcement is implemented. This effort will identify those engineering and enforcement measures requiring supplemental educational programs and create cost effective informational materials to meet these needs. It will also identify effective delivery mechanisms.

Current Knowledge and Practice

A variety of public safety educational information sources exist for pedestrians and bicyclists at the federal, state and local level. Both FHWA and NHTSA have catalogued bicycle safety information. However, much of the pedestrian safety information has not been catalogued. Dissemination of this information to the general public has been challenging. In both areas, very few of these materials have been evaluated for effectiveness. It is unknown what information exists regarding driver information about pedestrian and bicycle safety.

Rationale

The 3-Es, Engineering, Education, and Enforcement, supplement each other. Improvements in engineering are more effective when the intended operations of the engineering countermeasures are explained to the user audience.

- Better understanding by the public of the intended meaning and operations of the transportation system and consequences of misuse of the system.
- Tools that will aid transportation practitioners and enforcers to communicate with the public.

• Increased effectiveness of the safety improvements for all road users.

POTENTIAL BENEFITS

One would expect a reduction in pedestrian, bicycle and motorcycle fatalities with the improvement of the infrastructure. However, pedestrian, bicycle and motorcyclist safety are affected not only by infrastructure changes but also by road user attitudes and behaviors. In addition, the design of the infrastructure is constantly faced with the trade offs of providing optimum facilities for each type of transportation user. A 10 percent reduction in the number of pedestrian, bicycle and motorcyclist fatalities is a reasonable goal for this theme.

Safety is the number one-priority of all jurisdictions: federal, state, and local governments. Given this fact, the potential effect on the practice of deploying the safety products is good. In the National Quality Initiative, the public also rated safety as the top priority. The industry is somewhat involved in pedestrian and bicyclist safety. While they do not have significant research funding, they are very willing to coordinate with the research that is being conducted and help test the products.

Activities are required on all levels of research, development and implementation (technology transfer). Also, long term and applied research, as well as demonstration and evaluation of new methods are needed. With good technology transfer, the chances are good for deployment.

TRUCK AND BUS SAFETY

BACKGROUND

In 1998, 41,471 people were killed on our Nation's roads, and almost 3.2 million were injured. About 13 percent (5,362) of the fatalities involved large trucks; and 4 percent (142,000) of the injuries involved large trucks. In part, these statistics reflect the major role that commercial vehicles (mostly large trucks, but also motor coaches) play in our motor vehicle transportation system. Commercial vehicle operations in the U.S. account for nearly 400 B dollars in annual revenues and represent more than 80 percent of the nation's freight bill. Commercial trucks and buses represent nearly 10 percent of all registered motor vehicles and the industry employs 10 million people, including 3 million drivers.

The public importance of commercial vehicle safety is underscored by the fact that approximately two-thirds of all "harm" from large truck crashes, and approximately 86 percent of fatalities occur "outside of" the truck in 1999, i.e., to other vehicles and vehicle occupants involved in crashes with trucks. The vast majority of these crashes are due to human error – either of a non-commercial driver involved in the crash or of the commercial driver.

Commercial drivers are generally good drivers. The crash involvement rate per mile traveled of combination-unit truck (tractor-semitrailer) drivers is less than one-half that of noncommercial drivers. Commercial drivers are less likely than non-commercial drivers to seriously violate speed limits or engage in aggressive or risky driving behaviors. The majority of car-truck crashes are related more to the errors and misbehaviors of car drivers than to those of truck drivers. However, because of the high mileage exposure of trucks and the frequently severe consequences of their crashes, there is a premium on making trucks and truck drivers safer. Total life-cycle crash costs are more than four times greater for a combination-unit truck than for a passenger vehicle. The public has a right to expect commercial vehicle operations to exhibit a high standard of safety behavior and performance.

Commercial vehicles are also the platform of choice for early development, testing and deployment of many traffic safety interventions. Because per-vehicle crash costs are so much greater for trucks than for cars, there are greater per-unit benefits associated with crash reduction. More money and time can be invested in improving the safety of each vehicle and driver. And, since commercial vehicle travel is regulated by government and generally managed through fleet operations, there are better opportunities for controlled testing and evaluation of new safety interventions. For all of these reasons, commercial vehicle safety is a priority concern and interest in traffic safety.

RESEARCH NEEDS

Increase the Understanding of Truck and Bus Crashes and Their Precursors

Improvements are needed in data collection systems, methods to collect pre-crash data, uniformity of data collection, linking of relevant data bases and communication of data and findings to state and local officials managing safety initiatives. Furthermore, many of the precursors leading to truck and bus crashes are not easily discernible from crash investigation regardless of how in-depth or representative these investigations are.

Current Knowledge and Practice

Although the states and the federal government collect data on truck and bus crashes, our understanding of the genesis of these crashes is generally superficial and disjointed. A particular gap exists relating to crash causation. To date there have been no representative, in-depth commercial motor vehicle (CMV) crash causation studies, although a large collaborative FMCSA/NHTSA truck crash causation study is now underway. Available data suggest that many crashes involving large trucks and light vehicles, i.e., passenger cars and light trucks/vans, are due to the errors or misbehaviors of light vehicle drivers. Among those crashes involving a truck driver error, one common scenario involves trucks striking cars during lane change or merging maneuvers, in many cases due to driver failure to see the smaller vehicle. For one subset of the large truck crash population, fatal-to-the-truck-driver crashes, fatigue has been shown to be a major factor.

Rationale

These actions are necessary to improve our understanding of crashes involving trucks and buses in single vehicle crashes, as well as crashes involving interaction with light duty or passenger vehicles both prior to and during the event. This work will support the development of effective countermeasures and training programs to reduce crashes involving trucks and buses.

- More complete, accurate, uniform and timely data on CMV crashes.
- More in-depth and representative data on CMV truck crash causation employing a full taxonomy of causal and contributing factors.
- Instrumented vehicle, driving simulator and/or fleet-based reporting studies of driver errors or unsafe conditions likely to lead to crashes.
- Quantification, through a major, fleet-based case control study, of the role of multiple driver, vehicle and environmental risk factors associated with CMV crash involvement.
- More open, comprehensive, and systematic approaches to dissemination of CMV safety data and to evaluation and improvement of safety programs based on these data.

Reduce Driver Errors Resulting in Car/Truck Crashes

Research on the interaction of trucks with proximal "4-wheelers" and other road users includes Share-the-Road/No-Zone research as well as studies of large truck conspicuity, visibility and lane change/backing maneuvers. More information is needed to reduce the interaction between passenger and large displacement vehicles.

Current Knowledge and Practice

A majority of crashes involving light vehicles and CMVs involve an error or violation on the part of the light vehicle driver. Many of these crashes are caused by "proximity" errors by light vehicle drivers, such as tailgating or unsafe lane changes around large trucks. Truck drivers, while they generally exhibit safer driving behaviors and better compliance with traffic laws, are nonetheless prone to proximity errors such as visibility-related lane change, turning, merging and backing crashes.

Rationale

Increased public awareness of CMV no-zones and other operational limitations and improved CMV driver practices and performance around light vehicles will result in significant reductions in CMV crashes. Like other public safety information campaigns, these efforts are directed toward changing the public's knowledge, attitudes and driving behaviors.

- Improved public information and outreach messages and media for Share the Road and No Zone programs.
- Identification, pilot testing and implementation of changes to traffic codes to prevent car driver proximity errors around trucks and provide a traffic enforcement complement to the above public outreach programs.

- A CMV crash "near-miss" data collection initiative, most likely involving instrumented vehicles, similar to successful programs underway in aviation and maritime.
- Identification and assessment of improved mirrors and advanced technology devices to improve the visibility around trucks, in particular in blind spot/no-zone areas.
- Fleet-based safety training programs for CMV drivers focusing on space management around CMVs, e.g., headway management, blind spots, passing, merging and wide right turns.

Promote Heavy Vehicle Safety Equipment and Technologies

Large trucks have numerous physical and performance characteristics that increase their likelihood of crash involvement relative to smaller vehicles and, even more dramatically, increase the human consequences once a crash occurs. These characteristics include truck size, weight, structural stiffness, blind spots/zones, long stopping distances, reduced capability for evasive maneuvers and high center-of-gravity. While some of these characteristics are inherent to the vehicle, others are amenable to design improvement, particularly through the use of advanced technologies.

Current Knowledge and Practice

Current emphasis in this strategy is on the development, pilot testing and deployment of systems to recognize and help the CMV driver compensate for potential hazardous conditions, errors or inappropriate actions. The U.S. DOT Intelligent Vehicle Initiative (IVI) is the primary effort in this area. In many cases, proof-of-concept has been achieved for these technology applications, but they have yet to be operationally tested or widely deployed.

Rationale

This research will help prevent CMV crashes by reducing unsafe driving, e.g., speeding, tailgating and drowsiness, and by intervening to prevent specific crash types, in particular rear-

end, lane change, road departure and rollover crashes. Another strategy is to directly improve vehicle crash avoidance performance parameters, e.g., increase the speed and/or force of braking.

Expected Results

- Development and deployment of advanced sensors and related system components to continuously monitor the status of safety systems such as brakes and tires, as well as driver performance monitoring technologies such as speed, acceleration, headway and alertness monitoring.
- Safety performance and cost models to evaluate the safety benefits and economic impacts of technological advance and facilitate cost-beneficial applications.
- Expanded operational testing and deployment of collision warning systems, particularly for rear-end, lane change/merge and backing crash situations.
- Operational testing of Electronic Braking Systems (EBS) for both tractors and trailers with the eventual phase-out of air brakes and replacement by brake-by-wire disc brakes.
- Reduction in large truck aggressivity to smaller vehicles in crashes, e.g., through devices to
 prevent side underride, create better bumper-level compatibility with smaller vehicles during
 collisions and to better absorb collision forces.
- Improved truck cab occupant protection, particularly in rollover crashes.

Improve the Enforcement of Commercial Motor Carrier Safety Regulations

An essential element in CMV safety is compliance with federal and state safety regulations. The principal means by which these regulations are enforced are roadside inspections, on-site fleet safety compliance audits (compliance reviews), imposition of fines and, in extreme cases, criminal prosecution.

Current Knowledge and Practice

Improved methods and technologies have been applied to enforcement, most notably in the systems to collect and analyze enforcement data. However, there are numerous ways in which enforcement efforts can be further enhanced through research, development and testing.

Rationale

This strategy is directed toward improving regulatory compliance and enforcement, as well as studies of roadside inspection criteria and procedures, compliance reviews and the application of sanctions and penalties. Safety interventions to improve enforcement may be in the form of new technologies, procedures, information systems or information/education. These activities reduce crashes by improving CMV safety regulation compliance with regulations related to vehicle mechanical condition and driver operations, including hours-of-service.

- Integration of advanced sensors currently being incorporated into new heavy vehicle designs with roadside enforcement devices to enable reliable, at-speed safety inspections of brakes and other vehicle safety components.
- Development and pilot testing of voice recognition and other timesaving technologies to expedite roadside inspections.
- Expanded testing and promulgation of on-board electronic recorders to improve CMV driver hours-of-service compliance.
- Development, certification, and promulgation of third-party safety investigations and audits, with assurances of their quality and integrity.

Identify and Reduce the Crash Risk of High-Risk Carriers and Drivers

Because of limited government resources, only a fraction of motor vehicles are inspected at roadside and only a fraction of carriers are subjected to compliance reviews. There is a premium on improved targeting of enforcement activities and actions.

Current Knowledge and Practice

Major improvements have been made in the targeting of high-risk carriers for compliance reviews through the use of the "SafeStat" system, and this same algorithm is now used to target vehicles for roadside inspection.

Rationale

New motor carrier safety data systems will better prioritize drivers/vehicles for roadside inspection and carriers for compliance reviews and other enforcement actions, thereby greatly increasing the effectiveness of enforcement programs. This strategy also includes activities to identify high-risk drivers and prevent CMV drivers with revoked licenses from continuing to drive.

- A national Unified Carrier Register to replace current multiple registration programs and result in proper attribution of safety and exposure data.
- Improved national data systems for processing crash, driver citation, roadside inspection and motor carrier census data to make enforcement more systematic and targeted to high-risk carriers, with appropriate prioritization of passenger and hazardous materials carriers.
- Continued enhancements to the Performance and Registration Information Systems
 Management (PRISM) program, which ties state CMV registration to the safety fitness of carriers, thereby increasing leverage over carrier safety performance.

- New techniques and approaches for improving the compliance and safety performance of "new entrants" – companies just beginning motor carrier operations.
- Development, through analysis, of a CMV industry operational and safety profile to delineate crash risks and other safety-related characteristics of different industry segments, operations types and vehicle types.

Improve Commercial Driver Training and Performance Management

The vast majority of crashes are due to human error, and the propensity for such error varies widely among individual commercial drivers and among fleets. The quality of training given to commercial drivers and, even more importantly, the fleet safety management practices under which they work, significantly affect crash involvement rates.

Current Knowledge and Practice

A relatively small percentage of CMV drivers account for a disproportionate percentage of incidents. By and large, the major advances in industrial psychology and management science of the past 50 years that have been applied to military and industrial jobs have not yet been applied systematically to improving the safety of CMV drivers.

Rationale

This strategy encompasses a full spectrum of "human resource management" research and development activities addressing driver recruiting, selection, training, testing, licensing and safety performance management. New knowledge and technologies will reduce crashes by enhancing CMV driver performance both for entry-level drivers (a high-risk group) and for experienced drivers.

Expected Results

- Sophisticated National Advanced Driving Simulator (NADS) studies to define and calibrate basic parameters and elements of safe CMV driving and validate them in relation to real world driving.
- Improved methods for selection of candidate CMV drivers, validated in relation to crash involvement risk.
- Improved methods for training both novice and experienced drivers, including advanced technologies such as simulators, computer-based training and on-board performance monitoring.
- Improved methods and standards for testing and licensing including use of performance assessment technologies and graduated licensing programs.
- Improved carrier management practices to maximize safety motivation and behaviors.
- Identification, through crash investigation, advanced simulation and instrumented vehicle studies, of driver performance characteristics associated with crash risk and application of these findings to training and performance management.

Improve Driver Alertness and Fatigue Management

Fatigue is a safety issue of special concern to CMV transportation. CMV drivers may drive up to 10 hours continuously before taking a break, often drive at night and sometimes have irregular and unpredictable work schedules. Much of their mileage is compiled during long trips on Interstate and other four-lane roadways.

Current Knowledge and Practice

Previous research has shown that because of CMV drivers' far greater mileage exposure and other factors, their risk of being involved in a fatigue-related crash is far greater than that of non-

commercial drivers. In addition, fatigue is probably the largest single factor leading to CMV driver fatalities. It plays a major role in CMV driving safety.

Rationale

This strategy addresses future CMV driver hours-of-service issues as well as driver education/outreach and fatigue management. It supports crash reduction by decreasing the number of asleep-at-the-wheel crashes and, more importantly, improving the overall alertness and performance of CMV drivers.

Expected Results

- Continued research to refine hours-of-service rules to make them more science-based and better customized to the diverse operations of the truck and motor coach industries. In particular, this research should address daily and weekly time off and sleep requirements to ensure sufficient sleep and rest.
- New knowledge relating to specific CMV driving operational factors, such as sleep in truck sleeper berths, night driving and scheduling practices that impact driver alertness and safety.
- Identification, assessment, and deployment of fatigue-related technologies to monitor sleep, performance and alertness and help drivers manage their rest periods and work habits to obtain more sleep and perform better.
- Driver education and wellness programs that help CMV drivers improve their lifestyles and work styles to overcome the influences of chronic stress and fatigue attributable to many commercial vehicle operations.
- Expanded highway rest areas and commercial truck stops with information/ communication systems to inform CMV drivers where rest space is available.

Improve Driver Physical and Medical Fitness

There are four "absolute" CMV physical/medical qualification standards including vision, diabetes, hearing and epilepsy. In addition, there are several "non-absolute" guidelines, such as high blood pressure. Sleep apnea, though not a current qualification factor, is also a major emerging concern because of studies showing its association with crash involvements, and studies indicating that commercial drivers are likely at greater-than-average risk.

Current Knowledge and Practice

CMV driver physical/medical regulations have historically been based on consensus medical judgment as opposed to performance-based empirical research. There are legal, ethical and public safety needs to develop empirically derived, performance-based qualifications.

Rationale

This research will reduce crashes by ensuring that CMV drivers are physically and medically fit to drive. The intent is to move away from standards involving absolute prohibitions to ones that are responsive to individual abilities and needs and performance based. This is a difficult area because often there are conflicting interests between affected drivers wanting to work and the need to ensure public safety.

- Incorporation of the physical/medical certification process into the CMV driver licensing process.
- Performance-based physical/medical standards reflecting current scientific knowledge and validated in relation to CMV driving safety.
- Assessment of the role of sleep apnea on CMV driving safety and deployment of validated, performance-based sleep apnea screening devices.
- Quantification, through the conduct of a major, fleet-based case control study, of the role of

multiple physical, medical and other individual driver characteristics in crash risk.

 Subsequent re-examination of CMV driver physical/medical standards and practices based on the above research.

Improve the Highway Infrastructure and Operations in Regard to Truck and Bus Safety

Commercial vehicles are generally an order of magnitude (or more) larger and heavier than noncommercial vehicles. High centers-of-gravity make them vulnerable to rollover, and articulated vehicles are subject to jackknife. The physical margin of error on highways is much smaller for CMVs than for light vehicles. Infrastructure design features such as lane widths, radii of curves and roadside barrier sizes may have different safety effects on CMVs than on smaller vehicles.

Current Knowledge and Practice

Over the past decades, highway safety infrastructure improvements have contributed substantially to reduced truck and car fatality rates, and standards and manuals for road design and traffic control are available. However, there has been no systematic assessment of the role that infrastructure improvements can make in reducing large truck crash-related fatalities and injuries.

Rationale

This strategy attempts to reduce CMV crash risk through the improved design and operation of the nation's highways. These may relate to roadway design, especially divided highways, access control to roadways, operational practices such as truck routing or lane restrictions, incident management and facilities improvements, e.g., roadside hardware to reduce crash consequences. In many cases, a principal challenge is to demonstrate that such improvements can be made cost-effectively and in ways that are environmentally acceptable and sustain mobility.

Expected Results

- A comprehensive survey of infrastructure design and operational practices to identify issues most critical for CMV safety, and further to identify best practices for CMVs.
- Cost-effective means for minimizing truck-light vehicle conflicts, such as more divided highways and, in selected locations, exclusive highway facilities for commercial vehicles.
- Optimized (with regard to safety and mobility) operational control of CMV use of roadways, including restricted routing and lane usage.
- Resolution and consensus on the issue of whether differential truck-car speed limits on highways, i.e., lower speed limits for trucks, enhances or degrades overall safety.
- Demonstration of benefits and full implementation of highway treatments aimed at reducing driver fatigue and supporting night driving, such as roadside rumble strips and more visible signs and lane markings.
- Additional development of cost-effective roadside hardware, such as guardrails and barriers, capable of mitigating CMV crashes.
- Continued development of improved methods for CMV incident management.

POTENTIAL BENEFITS

The U.S. DOT has set a goal of "50 by 2010", a 50 percent reduction in commercial truck-related fatalities by the year 2010. Achieving this goal will save more than 2,500 lives annually compared to the present and would prevent thousands of injuries. The annual economic cost of large truck crashes is approximately \$15B dollars, and the average annual per vehicle crash costs is nearly \$6,000 per year for long haul combination-unit trucks. Crash reductions will result in large economic benefits in addition to the human benefits of reduced injuries and fatalities.

POST-CRASH MANAGEMENT

BACKGROUND

In the 2000 early assessment, 3,219,000 motor-vehicle crash injuries resulted in 41,800 deaths. Emergency medical systems (EMS) transport almost 85 percent of these injuries to emergency departments and 30 percent of these are admitted to the hospital. Although the development of trauma systems, which includes a pre-hospital care component, has a demonstrated mortality impact, the exact contribution that is made by pre-hospital care to mortality reduction is unknown. Furthermore, there is essentially no meaningful data on the impact that pre-hospital care has on non-mortality outcome measures for motor vehicle crash (MVC) victims. EMS care may have an impact on the ultimate level of disability these victims will have, the discomfort they experience and ultimately, the cost that society must pay for medical treatments, lost wages and rehabilitation.

This research-oriented EMS Initiative (EMSI) will improve the effectiveness of care delivered by pre-hospital personnel to motor vehicle crash victims and lead to the development of a model for EMS systems around the country to use for the treatment and evaluation of MVC victims.

The EMSI recognizes that post-crash management includes many activities, such as detection, notification, training, management, treatment, transportation, rehabilitation etc., but the component with the greatest need for research is EMS care.

RESEARCH NEEDS

Identify Effective EMS Interventions for MVC Victims in the United States

Prevention of death and injury mitigation is directly dependent on the ability to detect the

incident and treat or transport the injured victims to an appropriate facility in a timely fashion. Many EMS systems are in place but there are no specific guidelines or optimal models for their establishment.

Current Knowledge and Practice

Eighty-five per cent of MVC victims are transported by ambulance, yet there are no data available that describe what is being done for these individuals by the system. Furthermore, only 30 percent of these are admitted to the hospital. Substantial resources are being used on nonadmitted MVC patients. What exactly is being done for these people? Are transport and treatment really necessary? What is the impact of these treatments on non-transported patients? What are the outcomes of the 15 percent presented to emergency departments but not transported by EMS? These question and other have yet to be studied.

Rationale

Research on the scope of EMS care is essential for determining effective interventions.

Expected Results

- Effective and efficient EMS interventions.

Identify Measures which Improve Trauma System Effectiveness

This study is a cross-sectional, time-series analysis of crash mortality and morbidity data collected to show the outcomes of patients transported to emergency departments. The outcome measures will include morbidity, disability and health-related quality of life measures, as well as measurement of outcomes across the continuum of care. The study will need to incorporate a very large number of patients and treatment centers.

Current Knowledge and Practice

There has been no previous work in this area.

Rationale

The study will be used to develop guidelines and quality measures to guide both the structure and the process of EMS systems as well as interactions of the EMS system with other health care providers including managed care and other payers and policy makers. It may also provide the basis for predictive measures to guide treatment decisions.

Expected Results:

- Guidelines and quality measures for the structure and process of model EMS systems.
- Predictive measures for treatment decisions.

Identify Interventions and Technologies Associated with Better Outcomes

This will be a multi-site prospective observational study that looks at urban, suburban and rural systems from several geographic regions. It will also examine the difference in outcomes between Advanced Life Support and Basic Life Support providers. Information from the previous study will be critical to developing this study.

Current Knowledge and Practice

There has been no previous work in this area.

Rationale

Results from this study will not only identify those interventions that are effective, but also will offer insight into future beneficial interventions. In turn, hypotheses will be developed for testing in future studies.

- Identification of effective procedures that produce better outcomes.
- Recommendations and strategies for their widespread implementation.

Identify the Role That Intelligent Vehicle Systems Will Have on EMS Operations

An expert panel will be convened to review the results of the above studies and conduct an exhaustive literature review to determine what areas of IVS seem most promising for facilitating and improving pre-hospital care for MVC victims.

Current Knowledge and Practice

This activity has not been previously implemented.

Rationale

Convening a panel of experts will be essential for ensuring that promising study results are identified and implementation strategies are developed.

Expected Results

• Recommendations for current implementation and future research.

Develop Simulated Patient Training Using Emerging Electronic Technology

Clinical care of the severely injured MVC patient is extremely challenging and depends on set of sophisticated clinical skills that if used infrequently, may deteriorate. This is a particular problem for providers in rural areas where rates of MVC injury and death are higher than for non-rural areas.

Current Knowledge and Practice

State-of-the-art training for EMS system practitioners is generally through paper-based curriculum and classroom exercises.

Rationale

Paper and pencil exercises do not substitute effectively for rapid problem-solving and effective use of the psychomotor skills critical to the appropriate care of trauma patients. This research will combine simulated patient training with Web-based training and video conferencing.

Expected Results

• A technology-based trauma care training network that can be accessed by pre-hospital care personnel across the country.

POTENTIAL BENEFITS

This effort is a long-term research initiative. It requires the cooperation and commitment of the EMS /trauma research community. The long-term benefits will be profound in terms of the reduction in mortality and morbidity for not only those injured in MVC's but also for those involved in non-vehicle incidents.