Commission Briefing Paper 4J-01

Implications of Potential Strategies and Revisions to Infrastructure Design Standards to Improve Safety

Prepared by: Section 1909 Commission Staff
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Introduction

This paper is part of a series of briefing papers prepared for the National Surface Transportation Policy and Revenue Study Commission authorized in Section 1909 of SAFETEA-LU. The paper synthesizes the state-of-the-practice consensus on the implications of safety strategies, tools and infrastructure design standards.

This paper describes the scope and nature of the highway safety problem facing the U.S., which accounts for 94% of fatalities and 99% of injuries in the Nation's surface transportation system. It analyzes strategies such as a "focused" approach to safety and the comprehensive, data-driven and results-oriented Strategic Highway Safety Plan process required by SAFETEA-LU. It describes innovative approaches to safety through safety design techniques and tools. The safety implications of behavioral safety strategies and the importance of a comprehensive approach to safety are also discussed. The paper concludes with issues for the future including potential strategies and initiatives beyond SAFETEA-LU.

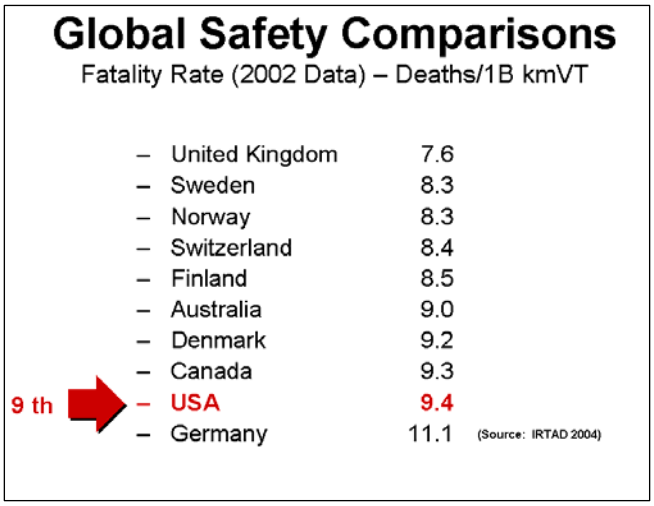
Background and Key Findings

The findings in this paper are based on analysis of data from the 2005 Fatality Analysis Reporting System, implementation of the safety provisions in SAFETEA-LU, state and local experiences with innovative safety techniques and tools, and research on long term policy initiatives to improve safety. Key perspectives include:

- More lives are saved with a data-driven, results-oriented, comprehensive approach to safety.
- Accurate and timely safety data are critical to the development of performance-driven strategies that maximize the effectiveness of safety projects and programs.
- Over half of highway fatalities in the U.S. occur on two-lane rural roads, and many of these roads are under the jurisdiction of local governments. Priority attention to this need and greater flexibility to focus resources and technical assistance on these roads is essential.
- Leadership commitment to highway safety throughout the transportation community is essential, including support for key safety policy and legislative actions.

Scope and Nature of Safety Problem

In 2005, highway fatalities rose 1.4% from 42,636 to 43,443. To get some perspective on the size of the highway safety problem in the U.S., we can compare our fatality level with fatalities in other developed countries (see Figure 1).



Why are our fatality numbers higher than many other developed countries? There are many reasons for this discrepancy. We have a much larger and diverse road network than most developed countries. Cultural differences play a major role. Federalism is the organizing principle for most public policy and governmental relationships in the U.S. It relies on the sharing of power between the federal government and the states. As a result, federal authority over transportation is more limited in the U.S. than in many other countries. Decision-making authority is dispersed among 50 states, instead of concentrated in one federal Department of Transportation, empowered to regulate and approve transportation improvements, interstate commerce and safety. The authority to enforce federal and state traffic laws is also delegated to the states and local governments. As a result, critical safety laws and safety programs and policies are sometimes missing or not consistently applied. How do we address this gap? It's important to consider the types of fatal crashes and the types of roads where they are occurring. This will help us determine the most effective strategies for reducing fatalities. Certain crash types play a major role in fatalities and serious injuries:

Roadway Departure	59%
Rural Roads	55%
Unbelted	52%
Alcohol Related	39%
Speeding	30%
Intersections	21%
Pedestrian	11%
Motorcyclist	10%

The highest number and rates of fatalities are found on certain types of roads. Over half of all fatalities occur on two-lane roads, primarily in rural areas. These are generally local and collector roads within the jurisdiction of local governments. In contrast, Interstates with the highest design standards have the lowest fatality rates. The fatality rate for rural local roads is more than three times larger than the fatality rate for urban and rural Interstates. As a result, SAFETEA-LU requires states to address traffic safety problems and opportunities on all public roads and have traffic records systems that include all public roads.

The following table provides the vehicle miles traveled (VMT), fatalities and fatality rate per 100 million VMT for roads within various function classes and split by rural vs. urban:

	RURAL							TOTAL RURAL AND URBAN
	Interstate	Other Principal Arterials	Minor Arterial	Major Collector	Minor Collector	Local	RURAL TOTAL	
VMT	258,790	233,999	164,933	193,288	58,299	128,628	1,037,937	
Fatalities	3,216	4,637	4,331	5,638	1,516	4,211	23,549*	

Fatality Rate	1.24	1.98	2.63	2.92	2.60	3.27	2.27	
URBAN								
	Interstate	**Other Freeways and Expressways**	**Other Principal Arterial**	**Minor Collector**	**Collector**	**Local**	**URBAN TOTAL**	
VMT	469,070	213,727	463,100	371,392	168,038	266,543	1,951,870	2,989,807
Fatalities	2,658	1,690	5,100	3,623	1,361	3,320	17,752*	43,443*
Fatality Rate	0.57	0.79	1.10	0.98	0.81	1.25	0.91	1.45
Note that the rural and urban fatality totals do not add up to the total for both facilities, as some fatalities are un-coded for the rural/urban category.								

Based on the information presented in the table above, urban interstates had the lowest fatality rate (0.57) of any class of roadways despite carrying the greatest volume of traffic. Rural local roads have the highest fatality rate (3.27) among all roadway function classes. Interstate roads have the lowest fatality rates because of the higher design standards and numerous safety features incorporated into this class of roads.

Three quarters of the nation's total road mileage is off the Federal-Aid System and two-thirds of this mileage includes local and collector roads where a disproportionate number of fatalities occur. Most of these roads are owned by local jurisdictions with meager resources to analyze problems and develop and implement effective safety programs or strategies.

An analysis of the types of crashes associated with the highest fatalities also shows that state safety needs vary widely. Roadway departure fatalities on both rural Interstates and 2-lane roads represent the most significant problem for many states. Intersection and pedestrian fatalities are particularly high in states that are highly urbanized or growing rapidly.

Strategies to Improve Highway Safety

Given the variety of state safety needs and the concentration of fatalities on the nation's most extensive set of roads with the lowest design standards, a "focused approach" to highway safety is needed. The Federal Highway Administration (FHWA) has responded by focusing additional resources to top-priority infrastructure safety needs. Priorities are identified through the use of data analysis and performance standards. In addition, tools and incentives are used to help "focus" limited safety dollars on the most effective safety measures with the greatest safety pay-offs. Crashes related to roadway departure, intersections and pedestrians are chosen as safety focus areas for the agency through analysis of national crash statistics and the potential impact of infrastructure countermeasures in addressing them. Use of safety belts and reduction of impaired driving and excessive speed are also critical safety focus areas targeted by the National Highway Traffic Safety Administration (NHTSA) and supported by the FHWA.

To significantly reduce fatalities and serious injuries, SAFETEA-LU increased the emphasis on safety activities by requiring states to develop and implement Strategic Highway Safety Plans (SHSPs). SHSPs must include a data-driven, results-oriented and comprehensive approach to safety that addresses engineering, education, enforcement and emergency medical services – the 4Es of safety – and must be developed in consultation with a specific set of safety stakeholders. SAFETEA-LU also gives states flexibility to use 10% of their safety infrastructure funds for non-engineering countermeasures that may yield the best safety results. To be successful, SHSPs rely on:

- Cooperation at all levels among engineering, enforcement, education and emergency services (4Es) professionals to use the best tools, countermeasures and strategies available to address safety problems.
- Data-driven decisions at all levels. States must create data systems that will allow leaders and highway professionals to assess the safety performance of the strategies, countermeasures and tools they select.
- Flexibility and /or increased emphasis on using available resources to address safety problems.

Highway Design Approaches to Safety

Highway design, the infrastructure side of the engineering "E" of safety, plays a significant role in improving highway safety. The fatality rate of the Interstate, which is 2 to 3 times lower than other roadway types, provides a dramatic example of the potential of using high design standards and aggressive safety countermeasures to reduce crashes. The FHWA is focusing its resources on three major crash types to improve infrastructure safety: roadway departure, intersection, and pedestrian crashes. In addition, a number of cross-cutting programs support infrastructure safety, such as work zones, visibility, older and younger road users, and speed management. The following is a brief description of the major focus areas, as well as cross-cutting efforts and analysis tools to support these programs.

Roadway Departure

Roadway departure crashes, which include vehicles leaving the roadway as well as head-on crashes, represent 59% of all fatalities. Two-lane rural roads are a particular concern, as vehicles have little opportunity to recover if they leave the pavement, and the opportunity for head-on (high energy) collisions is greater.

A number of life-saving strategies are available. Barrier systems are designed to mitigate the consequences of leaving the roadway, if a hazardous roadside object cannot otherwise be removed. Barrier systems may also be applied in the median of divided roadways to physically separate traffic and prevent head-on collisions from occurring. An example of this strategy being effectively implemented is the application of over 400 miles of cable barrier along the entire Interstate system in South Carolina. As a result of significantly reducing head-on collisions, South Carolina's cross-over median fatalities were reduced from approximately 30 annually to less than 5 annually. Sweden uses an innovative "2+1" design on rural roadways, alternating a continuous passing lane and separating the opposing lanes with a cable barrier system. This approach is being explored for use in the U.S. Rumble strips (longitudinal and transverse) have proven to be a life-saving countermeasure on shoulders of divided four-lane facilities, as centerlines on two-lane roadways, and at approaches to intersections and sharp curves. One state includes a 2-foot shoulder and rumble stripe (a rumble strip with a continuous painted edge line) as a safety feature on all two-lane road improvements. Other roadway departure safety features include the use of enhanced signing at strategic locations such horizontal curves, and the use of a "safety edge" (a 45-degree pavement fillet to provide a smooth tradition from the edge of an asphalt overlay to the existing surface – allowing vehicles to recover if they leave the roadway).

Significant future safety gains are possible through an aggressive use of strategies such as rumble strips, enhanced signing at locations such as horizontal curves, barrier systems to reduce or eliminate head-on and cross-over crashes, improved geometrics and shoulders, and proper establishment and maintenance of recovery areas.

Intersection

Intersection crashes represent 21 percent of all fatalities. This includes both signalized as well as unsignalized intersections. Intersection-related crashes represent more than 50 percent of all crashes in urban areas and 30 percent of all crashes in rural areas.

Safety strategies for intersections range from simple adjustments to the signal timing to innovative intersection designs. Traditional intersection safety strategies include improving horizontal and/or vertical sight distances, adding a protected-only left turn phase, improving advance signing, and installing lighting. Reducing the occurrence of red light running through camera enforcement can be an effective tool from an enforcement perspective. The installation of an innovative intersection design, such as a roundabout, can be an effective safety countermeasure. Roundabouts change the nature of crashes when they do occur, virtually eliminating the more severe "T-bone" crashes.

Highway-rail crossing crashes are a type of intersection crash. While the number of annual fatalities is small, approximately 330 of the 43,000 annual fatalities, they are usually catastrophic when they do occur. Further safety gains are possible through improvements to crossings (signs, signals, gates, etc.), technology innovations such as hump crossing detectors (detecting where a vehicle may be get hung up on the track due to the roadway's vertical cross section), and grade separations at strategic locations.

Future gains are possible in intersection safety with the aggressive use of countermeasures such as those noted above, design improvements, and the use of innovative intersection designs such as roundabouts.

In addition, the application of Intelligent Transportation System (ITS) technologies is promising for safety overall, and particularly for intersections. Systems that can detect and communicate potential collisions between vehicles have the potential of significantly reducing serious crashes and fatalities.

Pedestrian

Pedestrian fatalities represent 11 percent of all highway fatalities. While the pedestrian safety challenge is predominantly urban in nature, some states do have rural pedestrian issues.

The types of safety strategies effective at reducing pedestrian fatalities are similar to those effective for intersection fatalities. Adequate lighting can make a significant impact on pedestrian safety. Good delineation and advance signing are also important. Channeling pedestrian movements can improve safety, as the majority of pedestrian fatalities occur at mid-block locations. Where possible, separation of pedestrian traffic from vehicles through grade separated crossings or closure of streets can be effective. Traffic calming techniques that reduce and control speed are also important to increased pedestrian safety. In addition, adequate

sidewalks and walkways are critical to safe and efficient pedestrian movements. This is particularly important in areas such as school zones.

Pedestrian safety has the potential for significant improvement as well, with the aggressive use of pedestrian fatality countermeasures, by greater application of good access management programs, and by considering pedestrian needs as part of land use planning decisions.

Cross-cutting Programs

In addition to the three focus areas noted above, infrastructure safety can be advanced through cross-cutting programs. Work zone fatalities represent approximately 1,000 fatalities annually, and one of every five work zone fatalities is a highway worker. Work zone safety may be increased on all projects through proper planning and phasing; use of standard signing and markings; use of technologies such as work area intrusion alarms, queue detection sensors, and speed feedback signs; and strong enforcement. Older and younger road users experience a much higher fatality rate than the general population. Today's design standards are changing to more commonly reflect the needs of older users, and best practices are available for areas with a high percentage of older users. Standards that reflect the needs of older users also benefit all users of the transportation system. A good example is improved visibility. Improved lighting and adequate retroreflective signs and pavement markings allow all users to benefit from good roadway delineation and provide all drivers with the information needed to make safe decisions. Safety for youth is best addressed through education and enforcement efforts, including graduated licensing programs.

Of the cross-cutting areas, speed management has the greatest potential for significantly advancing safety. Speed management includes the education and training needed to set appropriate speed limits, enforcement to ensure compliance with appropriate speeds, and engineering roadways to encourage safe speeds. By reducing speeding, the severity of crashes can be reduced significantly in all of the infrastructure focus areas. Speed management strategies range from the application of automated enforcement, to traffic calming techniques. An engineering concept more commonly applied in Europe is the "self-explaining" roadway, whereby roadway features are designed to cause a natural reaction by the driver to reduce speed at critical locations. A more aggressive speed management program, involving the education, enforcement, and engineering elements of safety, could make a significant positive impact on highway safety in the United States.

Analysis Tools and Approaches

Innovative, performance-based analysis tools are being developed to better incorporate safety into program and projects. Three such tools include the Highway Safety Manual, the Interactive Highway Safety Design Module, and Safety Analyst. These tools can make a significant impact on decisions concerning safety by providing quantitative methods to evaluate the overall effect on safety and operations of geometric design decisions. However, to achieve the full benefits of these tools, broad dissemination, training, and technical support will be needed.

The new Highway Safety Manual will provide the best factual information and tools available to facilitate road investment and operational decisions, based on their safety consequences. It will provide state-of-the-art methods to select projects that can maximize the safety benefit of the dollars invested and insure the best possible safety performance. The first edition is scheduled

for completion by December 2008. The Interactive Highway Safety Design Module is a suite of software tools for analyzing individual projects. It will facilitate use of crash prediction methods for assessing the safety performance of existing or proposed highway geometric designs. A two-lane version is already available, and a multilane model is scheduled for completion by September 2008. Safety Analyst provides software tools for enhancing the highway safety by cost-effective means. It includes tools to identify potential sites for safety improvement, to diagnose safety problems, and to select and perform economic appraisals of countermeasures. Safety Analyst also includes a tool to perform before and after evaluations of countermeasures. It is scheduled for completion September 2008.

Another effective approach to safer road designs is the use of road safety audits (RSAs). To carry out an RSA, an interdisciplinary team of safety experts reviews the safety conditions on an existing road or the safety impacts of a design for a new road. The RSA team develops recommendations for the designer to consider for further enhancing the safety of the roadway, utilizing the expertise and knowledge of the team members. Broad application of the RSA technique to a wide range of roadways can be an effective strategy for advancing safety. Currently, RSAs are used by only a few states, and for only a handful of projects in those states. Wide scale use of RSAs would significantly increase the visibility of safety on a project level, and could result in significant safety enhancements on roadways.

Implementing Highway Design Strategies

The aggressive pursuit of highway design strategies offers the potential for significantly reducing fatalities. This can be accomplished through a combination of higher standards, broader implementation of existing strategies, and the development and implementation of new and innovative approaches. The development of new analysis tools will further assist designers and practitioners in making sound safety infrastructure decisions. Two-lane roadways offer the greatest challenge and opportunity for safety gains. Operations and maintenance efforts are also a key component of the overall highway design approach to improving safety.

Behavioral Safety Issues

The safe engineering of roads and roadsides is only one part of the safety equation. Without consistent improvement in driver behavior, traffic enforcement, and emergency medical services, dramatic reductions in highway fatalities will not occur, even with engineering improvements. To address these behavioral problems, NHTSA works closely with state and local governments to increase public education and awareness and support targeted enforcement campaigns. A comprehensive approach to safety including the 4Es has proven to be the best way to achieve significant reductions in fatalities and injuries on our highways. It allows safety professionals to consider the full range of safety tools to address problems, make the choice based on the most effective countermeasure, and implement strategies that may require not only an engineering fix but also targeted enforcement and greater public awareness.

Issues for the Future

This section describes the issues that are crucial to future progress and strategies that will help to address them. These issues include:

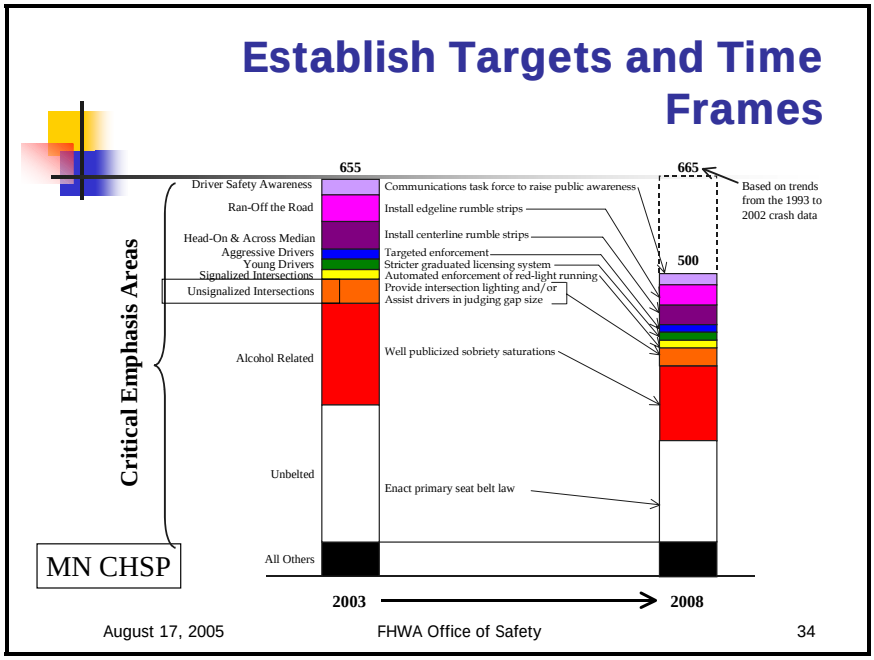
- Creating a Performance-Driven Environment.
- Keeping Leadership in the Transportation Community Engaged and Committed.

- Creating the Political Environment to Support Needed Regulatory Focus and Actions.
- Sufficient Funding and Other Resources to Meet Challenges and Issues.

Creating a Performance-Driven Environment

Leadership at the national level, emphasizing safety performance measured by accurate data, is helping to create a performance-driven environment for future safety investments. To improve performance, SAFETEA-LU calls for a data-driven approach to safety through the SHSP process, requiring states to develop goals to reduce fatalities and serious injuries as part of the SHSP, and use them to guide their implementation strategies. To measure and improve highway safety, SAFETEA-LU emphasizes the need for accurate and timely data to select the most effective goals, strategies and countermeasures. Goals are developed by each state through an assessment of its crash data and coordinated with other state safety programs. Goals should focus resources on areas of greatest need and address infrastructure and behavioral traffic safety problems and opportunities identified through data analysis to improve safety on all public roads.

Key national highway and safety organizations have also taken a leadership role in supporting a performance-driven approach to safety that has reinforced state and local efforts. States have adopted a wide variety of performance-based goals as part of their SHSP process. Some states have adopted the USDOT goal of achieving a fatality rate of 1.0 by 2008. Other states have adopted "vision zero", a long-term goal that envisions zero fatalities on highways. It includes incremental, performance-based goals in the state plan to ensure steady progress towards its "vision zero". Several states have based their goals on incremental improvements from their current fatality levels or rates. The table below shows the targets and time frames adopted by Minnesota to achieve its goal of reducing fatalities from 655 in 2003 to 500 by 2008. The table shows definite performance expectations for the strategies chosen, which include a comprehensive mix of '4E' initiatives.



Keeping the Leadership in the Transportation Community Engaged and Committed

A key component of aggressive and successful safety programs is a top-down commitment to highway safety. This commitment shows itself when politicians promote highway safety through effective policies and legislation; practitioners and professionals are actively involved in deploying highway safety countermeasures; and the general public supports change to save lives. Top-down leadership relies on the active support of leaders at the state, local and regional levels to succeed. Changes in traditional programs and methods to address driver behavior and infrastructure are needed to get America on a downward highway death trend. Without the support of key decision makers and elected officials, significant and sustained progress in reducing highway fatalities will not occur.

A coalition of national organizations representing state transportation and safety organizations is stepping forward to maintain the momentum of safety policy and program improvements included in SAFETEA-LU. Safety leadership forums in 2003 and 2005 helped state leaders to form the coalition and develop a consensus on key safety policies adopted by Congress. Top-down leadership from coalition leaders provided additional impetus to state efforts to develop and implement SHSPs. Another leadership forum is planned for the spring of 2007 to reinforce top-down leadership commitments to the coalition and begin the discussion of policies and programs to maintain the momentum of national safety progress.

Creating the Political Environment to Support Needed Regulatory Focus and Actions

To support major advances in safety performance, federal, state and local policies, legislation, and regulations need to be strengthened. Legislation that addresses primary seat belt laws and automated enforcement is especially important. Policies and legislation related to roadway design standards, use of technologies, and enhancement of vehicle safety standards are also critical to sustain gains in safety performance. A strong policy framework at the national, state, and local levels provides the needed backbone to support accomplishment of specific program goals and significant reductions in highway fatalities.

Sufficient Funding and Other Resources to Meet Challenges and Issues

Additional resources and greater program flexibility will be needed to help states improve their safety data systems, address the safety needs of non-state roads, and provide the training and technical assistance to disseminate new tools that can significantly improve safety performance. SAFETEA-LU raised safety to the level of a national priority by almost doubling the funds available for safety and creating a new “core” Highway Safety Improvement Program (HSIP). However, the data-driven decision-making process required by SAFETEA-LU relies on the collection and analysis of traffic safety data to develop programs that reduce crashes and fatalities. Timely, accurate, complete, uniform, and accessible data are needed to identify priorities for federal, state, regional and local highway safety programs. Reliable safety data provides the key to identifying hazardous highway safety locations and choosing the countermeasures that would be most effective and yield the greatest pay-off in lives saved in the most cost-effective manner. However, many states do not have safety data systems that can meet these needs. Upgrading or creating a new crash data system is complex and expensive. HSIP funds are available for data improvements but many other priorities will compete for limited funds. States will need increased resources to develop and maintain the safety data systems essential to achieving the benefits of the new data-driven program for saving lives.

SAFETEA-LU requires states to address traffic safety problems and opportunities on all public roads using traffic records systems that include data from all public roads. This requirement recognizes the disproportionate rate of fatalities on roads that are not part of federal aid or state highway systems. Safety improvements on rural or local roads that are not part of the state's road system will need funding. State SHSPs are supposed to consider all roads and determine where the greatest safety problems are and direct funds to those locations. If that is not done or if there is insufficient funding within the HSIP program to deal with roads on and off the state network, then additional funding will be required. Additional state flexibility and attention to the use of resources for non-state roads or non-engineering activities, identified as priorities by the SHSP, are also important.

Promising new safety tools such as the Safety Analyst, the Interactive Highway Safety Design Module and the Highway Safety Manual can assist safety practitioners and designers in making sound safety infrastructure decisions. To achieve the full benefits of these tools, they need to be broadly disseminated. Safety engineers throughout the country will need to be trained in the new techniques. Training and technical assistance will also be needed to educate and encourage safety practitioners to use innovative infrastructure designs and countermeasures.

Conclusion

With over 43,000 fatalities in 2005 and a non-declining fatality rate of 1.45 per hundred million vehicle miles traveled, our national safety performance is definitely not where we want it to be. However, we can make progress through aggressive implementation of SAFETEA-LU's data-driven, comprehensive safety strategies and the innovative safety design approaches and tools this paper describes. The challenges for the future are significant and need to be addressed on a continuing basis if we are to succeed. Issues for the future will always be with us and require close monitoring, consistent attention, and effective responses to achieve the level of safety performance that continually drives down highway fatalities and fatality rates on our highways.

CONSOLIDATED COMMENTS FROM MEMBERS OF THE BLUE RIBBON PANEL OF TRANSPORTATION EXPERTS - PAPER 4J-01

One reviewer commented as follows:

This paper describes the scope and type of highway safety problems facing the US. A brief comparison with some of the other developed countries is provided followed by reasons attributed to differences. The paper then briefly discusses the implications of potential safety improvement strategies, including a focused approach to safety; comprehensive, data driven and results-oriented strategic highway safety plan; behavioral safety strategies; and a comprehensive approach to safety. Highway design approaches to safety are discussed with focus on three types of crashes, namely, the roadway departure crashes, intersection crashes and pedestrian crashes. Various safety improvement measures corresponding to each of the crash types are summarized. A brief description of innovative and performance based analysis tools, such as "Highway Safety Manual", "Interactive Highway Safety Design Module", and "Safety Analyst", is provided. The

importance of the behavioral safety strategies in the improvement of safety is then discussed very briefly. On the whole, the paper provides a summary of various safety improvement strategies and describes the role each plays in safety improvement. The paper concludes by reviewing issues that will be crucial from the point of view of safety improvement in the future and also discusses potential strategies for safety enhancement beyond those in the SAFETEA-LU.

Safety is a critical issue. Any major future transportation initiative must address the problem of fatal and injury crashes in roads and highways. While a large portion of the road safety problem is driver behavior related, much can be done to design vehicles and infrastructures that can minimize crashes and enhance safety. It would be helpful if this aspect was explored in more detail.