Abstract Booklet

21st International Technical Conference
On the Enhanced Safety of Vehicles

15 – 18 June 2009

Stuttgart, Germany

ESV 2009 STUTTGART

21st ESV Conference Theme and Technical Session Topics

Conference Theme: "Reinventing Safety: Putting Advanced Technology to Work"

Data Acquisition and Analysis for Future Safety Enhancement
Chairperson: Ekkehard Brühning, Germany | *Co-Chair:* Koshiro Ono, Japan

For more than three decades accident reconstruction methods have been successfully used in investigating real-world crashes and determining causes of crashes and injuries. It is of value when the data lead to deployment of crash prevention and crash protection countermeasures. The usefulness of this approach in predicting future safety needs based on past historical data is becoming less useful because of the changing pace at which new technologies are coming in to the vehicle fleet. As the focus on countermeasures shift from crash protection to integrated safety, the need for crash causation data and its interpretation are becoming more critical. This session invites papers aimed at a discussion of future data collection and analysis methods such as naturalistic driving data on human-vehicle performance, analytical methods for estimating potential benefits of safety technologies, evaluation methods of video data, and universal descriptions of crash causal factors and resulting crash types. These methods are likely to serve as the foundation for detailed analyses of real-world crash data in developing countermeasures for safety enhancement and determining potential benefits of safety enhancement features in the future.

Developments in Frontal/Side Impact Protection
Chairperson: Bernie Frost, United Kingdom | *Co-Chair:* Dominique Charlebois, Canada

Two of the most predominant crash types that cause fatalities and injuries are frontal and side crashes. Much improvement in crash protection in frontal and side crashes has resulted from the design changes that have happened over the last two decades, especially in reducing fatal and serious injuries. Changes in vehicle fleet characteristics have also created a new problem with respect to incompatibility of vehicles involved in multi-vehicle crashes. The problems involved in frontal crashes and side crashes are distinctly different. Considerable amount of research has been undertaken worldwide to develop suitable metrics to assure structural engagement, for appropriate energy management, and to develop suitable countermeasures including the use of advanced technologies to improve crash safety in frontal and side crashes. Papers are invited to discuss the various strategies for frontal crash protection that are being pursued globally in this session.
Side impact protection has been a top crash safety priority in many regions of the world for more than a decade. The changing fleet characteristics and the advent of new technologies in vehicles necessitate a discussion of the latest research findings in this area. Papers in this session will also include various aspects of side impact protection, including safety countermeasures, test devices and procedures for their evaluation, and performance requirements and consumer rating program for side impact protection.

Vehicle Stability and Control Systems, and Rollover Prevention
Chairperson: Kyong Han Yoon, Korea | *Co-Chair*: Antonio Erario, Italy

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Advanced Vehicle Control and Safety technologies are being introduced into vehicles at a fast pace. For example, electronic stability control and traction control systems are already available in many vehicles today. The potential of anti-lock brake systems (ABS) for improving driver control has been well documented in controlled testing environments. Many other intelligent technologies that use ABS as the foundation for improving driver control for reducing many crashes of various types including rollovers are being introduced in production vehicles. This session is inviting papers that discuss the various technologies that are available or are being developed to improve vehicle stability and control that prevent rollover crashes and that assist drivers in preventing crashes of various types or reduce their severities when they occur.

Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety
Chairperson: Rodolfo Schöneburg, Germany| *Co-Chair:* Peter Robertson, Australia

Over the last three decades, considerable amount of efforts have been devoted to the protection of occupants during crashes. However, vehicle technologies that are evolving provide the opportunity to address safety continuously from crash prevention to crash severity reduction, crash protection and post-crash safety in an integrated fashion. Many new technologies are already on the road or are on the verge of introduction into vehicles. The use of these advanced technologies can help with new and innovative solutions to both current and emerging safety problems. They can supplement the traditional approaches related to crash avoidance, reduction of crash severity, occupant protection, post-crash safety and structural integrity of motor vehicles to provide integrated safety solutions. This session is intended to discuss papers related to research being carried out on this subject around the globe by research institutions, governmental organizations, suppliers and original equipment manufacturers.

Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development
Chairperson: Philippe Vezin, France | *Co-Chair:* Stephen Ridella, United States

To effectively and efficiently motivate the incorporation of appropriate safety countermeasures to address the multitude of automotive crash scenarios requires ever more diverse tools and robust injury criteria and test procedures. To advance the discussion on these items, this technical session invites papers to address (1) the development and application of analytical and experimental techniques to better understand the basic impact injury process, (2) techniques that enhance the identification of mechanical responses that are determinants of the injury outcome, and/or (3) processes that enhance the interpretation and predictive accuracy of dummy responses and injuries. Also included in this discussion will be the injury criteria capable of addressing real world injuries, anthropometric test devices and other related topics.

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Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Chairperson: Anders Lie, Sweden | *Co-Chair:* Andre Seeck, Germany

Advanced technologies are bringing new opportunities for enhancing safety in vehicles that never existed before. Driver warning and assistance technologies such as adaptive cruise control, road departure warning systems, and night driving systems are being introduced into production vehicles. These emerging technologies and concepts have great potential to improve safety. Examples of emerging technologies include braking systems that are being developed to assist the driver in braking and driver warning systems that alert the driver in imminent crash situations. The rapid introduction of these technologies to the market, while representing a positive direction in addressing safety concerns, has raised questions as to the level of safety benefits and practicability of many of these technological concepts. The key is to determine how well the technologies that are under consideration address the safety problems and to what extent they help in preventing crashes, in reducing their severities, and in protecting the occupants when crashes are unavoidable.

In estimating the safety benefits of these technologies, an analysis of the safety problems and target populations at each stage of the crash event is important. An important element in this process is the development of suitable test procedures that are objective and are related to real-world problems. Government regulatory and research bodies and vehicle manufacturers are examining concepts to predict the safety consequences associated with advanced technologies. Papers are invited on past and current research related to test and evaluation procedures and estimates of potential safety benefits and other performance issues related to driver assistance safety technologies.

Effect of Fuel Economy Strategies on Vehicle Safety

Chairperson: Jac Wismans, Netherlands | *Co-Chair:* Kyong Han Yoon, Korea

With rising oil prices, automobile manufacturers are under constant pressure to improve fuel efficiency of vehicles. Conventional claims have been that more fuel efficient vehicles are lighter and smaller and are not as safe as their heavier and larger less fuel efficient counterparts. In the age of advanced technologies for higher fuel efficiency and for enhancing safety, opportunities exist for both fuel efficiency and improved safety to coexist without the necessary trade off of fuel efficiency against safety. This session is inviting papers on the subject of strategies for improving fuel economy and safety, and on the impact of fuel saving vehicle designs on crashes and safety. Included in these will be papers that discuss ongoing research activities in advanced fuel saving and safety technologies.

Rear Impact Injury Prevention & Protection

Chairperson: Lynne Bilston, Australia | *Co-Chair*: Ola Boström, Sweden

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Rear impacts, though common, rarely cause fatalities and serious injuries. However, they result in a number of whiplash injuries that are common. Many researchers are pursuing this problem investigating causes of whiplash injuries and developing countermeasures that could prevent such injuries. Further, suitable test devices, and test procedures (dummies, barriers, etc.) and injury criteria are also under development. Many new technologies for rear crash prevention are also being developed. This session invites papers on these subjects as they apply to rear crash safety.

Additionally, backing crashes have the potential to cause a significant number of injuries and deaths to children and adults. Many new technologies are being introduced into vehicles that improve rearward visibility by direct and indirect means such as advanced mirror systems, cameras and sensors of various types. These systems also provide drivers with the necessary warnings and assistance in preventing rear crash occurrences. For the development of these devices, visibility metrics and other criteria that are objective are also needed. This session invites papers on the above topics as they apply to enhancing rear crash safety by preventing them, reducing their severity and protecting the occupants when such crashes occur.

Human Machine Interface - Issues, Driver-Vehicle Interaction Related Research, and Human Factors Guidelines Development

Chairperson: Claudio Lomonaco, Italy | *Co-Chair:* Lex van Rooij, Netherlands

Advanced Crash Warning Systems are being introduced into production vehicles by many manufacturers that have the potential to alert drivers of impending crash situations. Such warnings use haptic, visual and auditory cues to alert drivers. In some cases drivers are alerted to prepare themselves for a crash. Others exercise limited controls by braking and steering actions through feedback that prompt drivers to take actions. An important aspect of their introduction into the fleet in production vehicles is their potential to obtain safety benefits. At the same time there is also the potential for unintended safety problems, particularly if drivers are unfamiliar with the various types of systems that are brought into production vehicles by manufacturers. Another issue is that the effectiveness of such systems depends on the interface design and how well drivers are able to interact with them and improve their driving performance. Much research is also going on in various institutions on the issues related to human-machine interface design, appropriate evaluation techniques, and suitable metrics for such evaluations. Regulatory bodies and automobile manufacturers are also researching the human factors issues related to impaired driving. They are also investigating the usefulness of suitable guidelines. Papers are invited on research related to all of the above topics as they relate to human-vehicle interface designs and their evaluation to reduce impaired driving in this session.

Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Chairperson: John Hinch, United States | *Co-Chair:* Dominique Cesari, France

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It appears that the continued hope for significant safety benefits lies within pre-emerging and emerging vehicle technological advancements. Even though some of these technologies will be deployed voluntarily, deployment of those systems that are truly safety beneficial need to be accelerated through rulemaking actions, consumer information/education programs, insurance incentives, and other methods.

Introduction of technologies through regulations would only be possible after developing suitable evaluation protocols and after estimating the likely benefits that may result in solving real-world safety problems. This is especially important because regulatory bodies do not generally mandate technologies and they need to be based on total systems performance requirements. Further, safety performance of vehicle systems that are aimed at preventing crashes depend on the performance of driver-vehicle system. The success in preventing crashes in real-world situations would involve evaluation of vehicle response and driving performance as well. Proper analysis of crash data and objective evaluation procedures based on real world data is critical for deployment of safety technologies.
Another approach is to find other means such as dissemination of consumer information and use of market forces as drivers for deployment of safety technologies by automobile manufacturers. New Car Assessment Program (NCAP) type consumer information programs and other rating schemes can stimulate the deployment of advanced technologies.

Many manufacturers have already started on the path of introducing technologies under the banner of safety for everyone, integrated safety, all-around safety, and other such slogans. These are real attempts by manufacturers to find a means to use technologies in enhancing their vehicles' safety performance and at the same time to attract customers to those products that incorporate advanced technologies. Papers are invited on past, present, or planned deployment efforts related to bringing advanced safety technologies to the market.

Structural Integrity and Restraint Performance
Chairperson: Suzanne Tylko, Canada | *Co-Chair:* Steve Summers, United States

From the beginning of the twenty-first century, the state-of-the-art in motor vehicle safety has been going through significant changes. In-vehicle advanced technologies such as electronic stability control that apply corrective measures to augment control of the vehicle by the driver in critical situations are being deployed. Advanced technologies available in many of today's vehicles can warn the driver of imminent crash situations. Also, occupant protection can be improved through the development of advanced air bags that can tailor their performance taking into consideration occupant and crash characteristics.

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However, the design of future vehicles is also being driven by consumer demand for higher fuel economy and the concern for global warming. In addition to exploring hybrid, diesel, and alternative fueled vehicles, manufacturers are examining many other options. Manufacturers are examining ways to take weight out of their vehicles through the use of high strength steel and other light weight materials. Also, manufacturers are starting to offer very small "mini" and "micro" cars.

The focus of this session is on the structural characteristics and size and weight changes being explored and their effect on restraint systems performance that impact safety. Beyond today's advanced occupant protection safety technologies, will the smaller and/or stiffer cars of the future change the crash pulse significantly to necessitate new performance requirements related to structural integrity and occupant restraints in front and rear seating positions? What is the impact of compartment interior intrusion in crashes, on safety? What are the effects in different crash modes – frontal, side, and rollover? What are the countermeasures that could change the injury outcome in these situations? Would optimizing for safety and integrating structural and restraint performance be the best approach to enhance safety? These issues are receiving the attention of safety researchers world-wide. Papers are invited on research related to the safety impacts of structural and other characteristics of passenger vehicles of the future.

Vulnerable Road Users: Pedestrian Safety

Chairperson: Hideki Yonezawa, Japan | *Co-Chair:* Wojciech Przybylski, Poland

Pedestrian protection using autonomous vehicle based solutions has been the focus of research worldwide for many years. Much progress has been made in this area. The primary vehicle oriented countermeasures are centered on improving frontal structure of passenger vehicles to mitigate head injuries and improving lower extremity injuries. However, pedestrian safety continues to be a serious problem in several countries. In many areas, in addition to vehicle-based solutions, infrastructure related solutions are also being explored. Advanced technology systems using radar, vision concepts and other types of sensors are being investigated to identify pedestrians at intersections and to potentially provide warnings to drivers. Papers are invited in this session to address the issues faced by pedestrians and bicyclists.

Advances in Vulnerable Occupant Protection Systems

Chairperson: Jerzy W. Kownacki, Poland | *Co-Chair:* Donald MacDonald, United Kingdom

Occupant protection systems are generally regulated by safety performance requirements established through vehicle safety standards. These standards exist for frontal and side crash protection and in other areas of safety in many countries world-wide. However, these requirements are generally based on the 50th percentile male population even though safety benefits could result for other population as well.

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Many of these standards are now incorporating additional requirements based on 5th percentile dummies. However, a concern that remains is how well the current requirements extend to other vulnerable population such as the elderly and children. Additionally, does protection for the 50th percentile occupant at one speed compromise the protection for other occupants including children and small adults and the elderly? Even when child restraint systems (CRS) are used in transporting children in vehicles, and there are separate requirements for CRS based on sled testing, it is unclear how well the combination of the vehicle and the vehicles' own restraint systems along with the CRS would provide optimum safety. Another issue is safety of occupants in vehicles that use alternate fuels such as hydrogen and hybrid vehicles and the potential for fire and other safety concerns. In this session, papers are invited on all such topics that address safety of occupants that are vulnerable in motor vehicle crashes.

Advances in Truck Safety/Bus & Two Wheel Vehicles Safety

Chairperson: Matolcsy Mátyás, Hungary| *Co-Chair:* Steve Sopp, United Kingdom

Safety technologies for trucks and buses are topics that have received immense attention in past ESV conferences. This ESV conference will continue to focus on those technologies, and also explore research in the human-vehicle response area. With increasing attention on driver performance, are the safety technologies that can assist drivers of large vehicles in a pre-crash environment able to lessen or prevent a crash scenario from leading up to a crash involving smaller vehicles? Are these technologies capable of assisting drivers when they are drowsy and fatigued under long and tedious hours of operation?

Motorcycle crashes are a cause of serious concern globally. In the United States alcohol use and speeding are cited as major contributing factors in crashes. Non-use of helmets is another concern. Many of these same problems exist in various other regions as well. Motorcycle rider education and licensing, reducing the number of impaired motorcyclists on the road, increasing motorists' awareness of motorcycles and other vehicles on the road, use of advanced technologies, and increased helmet use are appropriate means to improve motorcycle safety. Technical papers are invited on these subjects for this session. Any potentially new technologies that address any aspect of motorcycle safety are also invited for this session. The safety of two-and three-wheeled vehicles using alternate fuel is also of particular interest in certain jurisdictions of the world. Technical papers on research related to these safety issues and potential solutions are invited for this session.

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Oral Presentations

Technical Session
Data Acquisition and Analysis for Future Safety Enhancement

Oral Presentations | Tuesday, June 16th, 2009 | TRACK A | Room C4

Time: 09:00-12:30

Chairperson: Ekkehard Brühning, Germany
Co-Chairperson: Koshiro Ono, Japan

Paper No. 09-0214-O

Crashes that Result in Fires

Kennerly H. Digges
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Abstract:
NASS and FARS data were analyzed to determine the crash environments that produced major fires. Case reviews were conducted for NASS cases with a major fire. Annually, there are about 400 fatalities in FARS with fire as the most harmful vehicle event. There are about 60 cases annually in NASS with a fire recorded. FARS years since 1978 and NASS years since 1997 were studied. NASS and FARS fire statistics for different crash modes with documented fires are presented. Also included are plots of deformation profiles for NASS vehicles with fires. These plots show damage profiles at the 10%, 25% and 50% frequency of occurrence levels. The frontal crash mode accounts for about half of the fires in FARS and NASS. Rollovers account for about 25% of the major fires in NASS and carry the highest risk of fatality in FARS fires. In NASS, the vast majority fires that occur in frontal and rollover crashes originate under the hood. Incapacitation and entrapment of occupants are important survival factors when underhood fires occur.

Paper No. 09-0199-O

How Often Do Front Airbags Fail To Deploy In Fatal Frontal Crashes?

Elisa R. Braver, Anne T. McCartt, Christopher P.
Sherwood Laura Fraade-Blanar
I*nsurance Institute for Highway Safety, United States*
Marge Scerbo
National Study Center for Trauma and EMS University of Maryland, Baltimore, United States

Abstract:
Objective – Public concern has arisen about the reliability of front airbags because Fatality Analysis Reporting System (FARS) data indicate many non-deployed airbags in fatal frontal

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crashes. However, the accuracy of airbag deployment, the variable in question, is uncertain. This study aimed to provide more certain estimates of nondeployment incidence in fatal frontal crashes.

Methods – Fatally injured passenger vehicle drivers and right-front passengers in frontal crashes were identified in two US databases for calendar years 1998-2006 and model years 1994-2006: FARS, a census of police-reported fatal crashes on public roads, and National Automotive Sampling System/Crashworthiness Data System (NASS/CDS), a probability sample of towaway crashes. NASS/CDS contains subsets of fatal crashes in FARS and collects detailed data using crash investigators. Front airbag deployment coding for front-seat occupant fatalities was compared in FARS and NASS/CDS, and case reviews were conducted.

Results – Among FARS frontal deaths with available deployment status (N=43,169), front airbags were coded as not deployed for 18% of front occupants. In comparison, NASS/CDS (N=628) reported 9% (weighted estimate) nondeployment among front occupants killed. Among crashes common to both databases, NASS/CDS reported deployments for 45% of front occupant deaths for which FARS had coded nondeployments. Detailed case reviews of NASS/ CDS crashes indicated highly accurate coding for deployment status. Based on this case review, 8% (weighted estimate) of front occupant deaths in frontal crashes appeared to involve airbag nondeployments; 1-2% of deaths represented potential system failures where deployments would have been expected. Airbag deployments appeared unwarranted in most nondeployments based on crash characteristics.

Discussion – FARS data overstate the magnitude of the problem of airbag deployment failures. There are inherent uncertainties in judgments about whether or not airbags would be expected to deploy in some crashes. Continued monitoring of airbag performance is warranted.

Paper No. 09-0553-O

A Classification Model For Prediction Of Rollover Crash Severity

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Santokh Singh
URC Enterprises, Inc. Olney, MD, United States

Abstract:
Crash severity can be defined as the potential of a crash to cause an injury or fatality. In the National Automotive Sampling System – Crashworthiness Data System (NASS-CDS), the crash severity of a rollover is assessed by estimating the magnitude of maximum intrusion and crush in the damaged vehicle. Several studies have shown that the number of quarter turns and roof intrusion are significant factors influencing the injury outcome. These studies

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mainly investigate the relationship between injury severity and vehicle-, crash-, or occupant-related variables. The purpose of this study is to develop a model that uses both vehicle-and crash-related parameters to estimate the rollover crash severity based on injury outcome. In this study, the data mining technique called discriminant analysis is used to build a predictive model. Of the several rollover-related variables considered as candidate predictors, the maximum intrusion, number of quarter turns, and estimated distance from trip point to final rest position show significant correlations with the maximum abbreviated injury scale (MAIS) and hence are selected as predictors for the model.
Since one of the predictors, the estimated distance from trip point to final rest position, was introduced in the NASS-CDS data in 2006, this study is based upon two years (2006 and 2007) of data. To eliminate the confounding effect of external sources of injury, only non-ejected occupants are considered. The data is also screened to include only the maximum intrusion in the vehicle and the occupant with maximum MAIS in the vehicle.
The discriminant function is used in building the model. Given the specific values of the predictors for a rollover case, the final model predicts the injury outcome in rollovers as minor, moderate, and severe with sufficient accuracy. The model can be used to extract comparable rollover cases to understand injury mechanisms that can be used to develop vehicle crashworthiness countermeasures.

Paper Number 09-0370-O

Intersection Road Accident Causation: A European View

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CEESAR (Centre Européen d'Etude de Sécurité et d'Analyse des Risques)
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LAB (Laboratoire d'Accidentologie de Biomécanique et de comportement humain, PSA Peugeot Citroën, Renault
Y. Page
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Abstract:
Intersections represent 43% of Europe's injury accidents and 21% of fatalities. Although specifically targeted, intersection accident mechanisms merit further investigation.

This study, part of the European TRACE project (Traffic Accident CaUnited Statestion in Europe), analyzes specific intersection accident caUnited Statestion issues from systemic viewpoints (driver, vehicle and environment) and risk factor research angles (visibility problems, speed, manoeuvres, etc.). CaUnited Statestion analysis uses a three-step methodology. A macroscopic approach highlights the frequency and severity of accidents and determines key scenarios. A microscopic approach, details accident causes. Because the driver plays an important role in the accident process, a dedicated "Human Functional Failure (HFF) analysis" is employed. Finally, risk factors are identified and related to accident configurations. Project partners and the CARE database supply national and European data. Because CARE does not contain data from all 27 countries, statistical adjustment was

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necessary. Partners also provided in-depth databases. The HFF concept is new and necessitated common codification of related data. Intersection accidents are grouped by common characteristics, such as road layout, driver manoeuvres... Macroscopic analysis identified 3 main scenarios. The “cutting” scenario groups initial perpendicular trajectories and covers 53% of European intersection accidents. The “turn across” scenario combines accidents involving turning manoeuvres on the same road, different direction. Finally the “other” scenarios include rear-end collisions. In-depth analysis furthered understanding of accident mechanisms and showed mechanisms and countermeasures to be directly linked to right of way rules. In “cutting” scenarios for example, 60% of drivers without “right of way” failed to look and react before crash, while 70% of opponent drivers braked before impact. Results suggest that the former need help to improve opponent and situational perception while the latter need improved braking and evaluation for earlier avoidance manoeuvres. HFF and related factor identification enable the association of current preventive or curative systems with observed driver needs.

Paper Number 09-0234-O

Automatic Incident Detection And Classification At Intersections

Jorge Alejandro León Cano, Jordanka Kovaceva, Magdalena Lindman, Mattias Brännström
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Abstract:
Collisions at intersections are common and their consequences are often severe. This paper addresses the need for information on accident caUnited Statestion; a knowledge that can be used to obtain more effective countermeasures. A novel method that can be applied to data recorded in a ground-based observation system or similar is proposed for classifying vehicle interactions into a set of predefined traffic scenarios. The classification is based on possible combinations of trajectories of two interacting vehicles that have passed through an intersection. Additionally, the authors present an incident detection algorithm that uses the classified vehicle interactions. This algorithm constitutes the core of a video-based automatic incident detection at intersections (AIDI) system. The performance of the AIDI system was successfully verified both in a driving simulator and in real traffic conditions.

Paper Number 09-0269-O

Widespread Collection of Real-World Crash Data Using Advanced Automatic Collision Notification and Medical Data Technologies

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Program for Injury Research and Education (UMPIRE)/
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Abstract:
Standard methods of investigating real-world crashes are hampered by the rapid rate at which the vehicle fleet changes as well as logistical hurdles involved in collecting sufficient quantities of data regarding specific vehicle and crash conditions to draw useful conclusions regarding injury caUnited Statestion. This degrades the ability of real-world crash data to contribute in a timely fashion to the assessment and improvement of vehicle and occupant protection systems.
The University of Michigan Health System, General Motors and OnStar are collaborating on a project to collect real-world crash data using the OnStar system to identify and screen crash cases from around the US. For crash events of interest, informed consent is obtained, medical interviews are conducted and the vehicle is inspected for photographic documentation. Medical records and digital medical imaging data files are also obtained for determination of injury mechanism and outcome.
Most real-world crash data collection systems have limitations. Systems in which a small subset of crashes is randomly sampled have very limited numbers of crashes from specific vehicle models and crash conditions. Geographically based census collection systems can have the same limitation. Medically based crash data collection systems provide optimal detail and insight regarding injury caUnited Statestion factors, but are also biased by being outcome-sampled and expensive. The novel use of advanced automatic collision notification technology for screening allows researchers to very efficiently identify the subset of real-world crash cases that hold most value for assessment of injury risk or evaluation of vehicle safety performance. Cost effectiveness will increase even further once photographic documentation of crash damage is no longer necessary. The involvement of independent, academically based medical researchers significantly enhances subject enrollment and enables the collection of sensitive medical records and digital imaging data.

Paper Number 09-0282-O

Development Of The Accident Investigation And Data Handling Methodology In The Gidas Project

Andre Seeck, Jost Gail
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Raimondo Sferco
Ford Motor Company Germany
Dietmar Otte
Medical University Hanover, Germany
Lars Hannawald
VUFO GmbH, Germany
Hans Zwipp
Medical University Dresden, Germany
Jörg Bakker
Daimler AG, Germany

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Abstract:
Since its beginning in 1999, the German In-Depth Accident Study (GIDAS) evolved into the presumably leading representative road traffic accident investigation in Europe, based on the work started in Hanover in 1973. The detailed and comprehensive description of traffic accidents forms an essential basis for vehicle safety research. Due to the ongoing extension of demands of researchers, there is a continuous progress in the techniques and systematic of accident investigation within GIDAS. This paper presents some of the most important developments over the last years. Primary vehicle safety systems are expected to have a significant and increasing influence on reducing accidents. GIDAS therefore began to include and collect active safety parameters as new variables from the year 2005 on. This will facilitate to assess the impact of present and future active safety measures. A new system to analyse caUnited Statestion factors of traffic accidents, called ACASS, was implemented in GIDAS in the year 2008.
The whole process of data handling was optimised. Since 2005 the on-scene data acquisition is completely conducted with mobile tablet PCs. Comprehensive plausibility checks assure a high data quality. Multi-language codebooks are automatically generated from the database structure itself and interfaces ensure the connection to various database management systems. Members of the consortium can download database and codebook, and synchronize half a terabyte of photographic documentation through a secured online access. With the introduction of the AIS 2005 in the year 2006, some medical categorizations have been revised. To ensure the correct assignment of AIS codes to specific injuries an application based on a diagnostic dictionary was developed. Furthermore a coding tool for the AO classification was introduced.
All these enhancements enable GIDAS to be up to date for future research questions.

Paper Number 09-0245-O

A New Approach Of Accident Causation Analysis By Seven Steps ACASS

Dietmar Otte, Michael Jänsch
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Abstract:
As the official German catalogue of accident causes has difficulty in matching the increasing demands for detailed psychologically relevant accident caUnited Statestion information, a new system, based on a “7 Steps” model, so called ACASS, for analyzing and collecting caUnited Statestion factors of traffic accidents, was implemented in GIDAS in the year 2008. A hierarchical system was developed, which describes the human caUnited Statestion factors in a chronological sequence (from the perception to concrete action errors), considering the logical sequence of basic human functions when reacting to a request for reaction. With the help of this system the human errors of accident participants can be adequately described, as

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the causes of each range of basic human functions may be divided into their characteristics (influence criteria) and further into specific indicators of these characteristics (e.g. *distraction from inside the vehicle* as a characteristic of an *observation-error* and *the operation of devices* as an indication for *distraction from inside the vehicle.* The caUnited Statestion factors accordingly classified can be recorded in an economic way as a number is assigned to each basic function, to each characteristic of that basic function and to each indicator of that characteristic. Thus each caUnited Statestion factor can be explicitly described by means of a code of numbers. In a similar way the caUnited Statestion factors based on the technology of the vehicle and the driving environment, which are also subdivided in an equally hierarchical system, can be tagged with a code. Since the causes of traffic accidents can consist of a variety of factors from different ranges and categories, it is possible to tag each accident participant with several caUnited Statestion factors. This also opens the possibility to not only assign caUnited Statestion factors to the accident causer in the sense of the law, but also to other participants involved in the accident, who may have contributed to the development of the accident. The hierarchical layout of the system and the collection of the caUnited Statestion factors with numerical codes allow for the possibility to code information on accident causes even if the caUnited Statestion factor is not known to its full extent or in full detail, given the possibility to code only those cause factors, which are known. Derived from the systematic of the analysis of human accident causes ("7 steps") and from the practical experiences of on-scene interviews of accident participants, a system was set in place, which offers the possibility to extensively record not only human caUnited Statestion factors in a structured form. Furthermore, the analysis of the human caUnited Statestion factors in such a structured way provides a tool, especially for on-scene accident investigations, to conduct the interview of accident participants effectively and in a structured way.

Paper Number: 09-0162-O

Simulation Of Real Crashes As A Method For Estimating The Potential Benefits Of Advanced Safety Technologies

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Abstract:
Since secondary safety systems have been implemented in modern cars successfully, the development of primary safety systems becomes more and more important. That causes the necessity of useful methods to estimate the benefit of these advanced safety systems. In this paper a new method for the benefit estimation of advanced safety systems by simulating real world crashes is presented.
The bases of this simulation are real world crashes out of the GIDAS (German In-Depth Accident Study) database, including reconstruction data, accident sketches and safety systems specifications.
The result of this method is a comparison between the simulated real accident scenario and the predicted accident scenario using a virtual prototype of the safety system. Using this

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comparison it is possible to estimate the benefit for the single case as well as the global benefit for all cases. The simulation will be done with a car dynamic simulation program. Therefore, interactions between sensor systems, brakes and steering controls can be considered.
Furthermore, it is also possible to simulate crash involved cars with more than one safety system. The benefit will be estimated regarding accident avoidance and/or accident mitigation based on all available cases in GIDAS.
Another possibility of such a simulation is to find out potentials of the further development of advanced safety systems or to develop new activating strategies by checking up parameters like yaw-angle, lateral acceleration or steering wheel angle.
This paper explains a method for the estimation of potential benefits of primary safety systems and exemplified results.
The paper offers the possibility of a dynamic simulation of real world accident initiations with and without virtual safety systems. The results provide detailed information about useful combinations of advanced safety systems.

Paper Number 09-0057-O

Side Pre-Crash: A Preliminary Analysis & Evaluation Of Crash Causation And Potential Safety Benefits

Madan Gopal ,Kevin Hawes, Rana Balci
Delphi Corporation, United States

Abstract:
With significant benefits achieved with frontal/side and rollover passive safety systems and additional improvements coming on board with frontal active safety, it is natural to consider extension of similar systems to side impact. In this paper, we have made an attempt to understand the side impact crash caUnited Statestion, vehicle kinematics and occupant restraints benefits with early deployments to quantify the problem and evaluate potential benefits.
Using NASS/CDS & FARS 2000-2006 database, we have identified top 10 crash conditions (AIS 2+ injury and fatalities) and looked at select cases for each through accident reconstruction tools to better understand the vehicle kinematics prior to contact. This approach also has given us an initial view of potential 'zones' on the vehicle where active systems can best be deployed to improve detection while reducing potential for false alarm. Also, a preliminary analysis through simulation and testing of early deployment of conventional passive systems compared to standard crash sensing shows a potential for significant injury reductions.

Paper Number 09-0375-O

Study On Pre-Crash And Post-Crash Information Recorded In Electronic Control Units (ECUS) Including Event Data Recorders

Hirotoshi Ishikawa, Nobuaki Takubo, Ryo Oga, Kenshiro Kato, Takeshi Okuno

Technical Session
Data Acquisition and Analysis for Future Safety Enhancement

National Research Institute of Police Science, Japan
Katsumi Nakano
Criminal Investigation Laboratory of Gifu Prefecture Police Head Quarters, Japan
Takahiro Ikari
National Agency for Automotive Safety and Victim's Aid, Japan

Abstract:
It is known that some Electronic Control Units (ECUs) that are installed in a vehicle can record pre-crash and/or post-crash information in an accident. The aim of this study is to understand the availability and usefulness of the ECU data and to develop various analysis methods enhancing the accident investigation. With respect to ABS-ECU, engine-ECU, and Event Data Recorder (EDR), two types of crash test data are analyzed in this study. The first type is the JNCAP crash tests, for understanding the EDR characteristics under standardized crash test conditions. The second type is the real-world accident reconstructions for evaluating the performance of those ECUs under highly complex and/or severe crash conditions, including multiple rear-end collisions, car-to-car side impacts, and frontal and side pole impacts. The data obtained from ECUs are compared with the results from the instrumented sensors. The study concludes that, the pre-crash velocities recorded by the EDR were highly accurate and reliable when cars proceeded without braking prior to the collision. The accuracy and reliability of the EDR impact velocity could be affected by the braking conditions and the EDR time zero information. The accuracy and reliability of the maximum delta-V recorded by the EDR decreased under highly complex or severe crash conditions, especially in the pole impacts. The EDRs underestimated the maximum delta-V in almost all the J-NCAP tests. The difference between the EDR maximum delta-V and the reference value was greater than 10 % in 4 of 14 tests. One of the factors responsible for this result might be attributable to the characteristics of the accelerometers used in EDR. Diagnosis freeze data recorded in ABS-ECU and engine-ECU have a potential to be utilized for the accident investigation by providing additional pre-crash vehicle information. However, further study is needed for understanding the reliability and accuracy of the diagnosis freeze data.

Paper Number 09-0452-O

Feasibility Of Using Event Data Recorders To Characterize The Pre-Crash Behavior Of Drivers In Rear-End Collisions

Hampton C. Gabler
Virginia Tech, United States
John Hinch
U.S. DOT / National Highway Traffic Safety Administration, United States

Abstract:
This paper investigates the feasibility of using event data recorders (EDRs) to

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characterize the crash avoidance behavior of drivers involved in rear end collisions. The study is based upon the records of 112 crashes from NASS/CDS 2000-2007 with associated EDR pre-crash data and of sufficient severity to deploy the frontal air bag. The study examined three factors affecting driver response to an impending rear collision: driver age, driver alcohol use, and road lighting condition. Crash avoidance actions of the drivers were inferred from the pre-crash EDR records of vehicle speed, throttle position, engine speed (RPM), and service brake status five seconds prior to impact. Factors considered included time of brake application prior to impact, peak braking deceleration, and the time history of throttle position. For these cases, this study combined EDR pre-crash records with NASS/CDS case records including scene diagrams and site photos to determine driver crash avoidance actions.

Paper Number 09-0510-O

The Vision of Accident Free Driving – how efficient are we actually in avoiding or mitigating longitudinal real word accidents

Helmut Schittenhelm
Daimler AG

The Vision of Accident Free Driving – how efficient are we actually in avoiding or mitigating longitudinal real word accidents Advanced technologies in environmental sensing, situational perception and new actuators that allow individual situational based interventions in braking, steering or controlling the chassis characteristics are giving new option for the enhancement of automotive safety. Especially primary safety and pre-crash system profit from these new opportunities and their potentials. The vision of an “accident free driving” was born. In a first wave advanced systems for mitigating or avoiding longitudinal accidents were developed and were actually penetrating into the market. Therefore the question of the safety benefit that is achievable with these systems in real world accidents arises. Development objective for primary safety measure is the avoidance of accidents. But avoided accidents are not contained in an accident data base. Thus the efficiency of a primary safety measure in contrast to a secondary safety measure can not be determined directly from accident data. The fture challenge is to extract components needed from methods like accident reconstruction, driving simulator tests or naturalistic driving studies, reassembling them in a new method to be able to estimate the safety benefit of an advanced systems usually consisting of warning and reacting components. This paper discusses future requirements of these components, their establishment and of accident data and its collection. It deals with the methodology to perform assessments of statistical representative efficiency. To be able to carry out an investigation concerning the efficiency in a transparent and comparable way basic definitions and systematics were introduced. Based on these definitions different systematic methods for estimating efficiency were discussed and related to each other. The paper is completed by estimating the safety benefit in real world accidents of actual purchasable Mercedes-Benz safety systems for assisting the driver in longitudinal accidents.

Oral Presentations

Technical Session
Developments in Frontal/Side Impact Protection

Oral Presentations | Tuesday, June 16th, 2009 | TRACK B | Room C5

Time: 09:00-12:30
Chairperson: Bernie Frost, United Kingdom
Co-Chairperson: Dominique Charlebois, Canada

Paper Number 09-0185-O

Comparison Of University Of Michigan CIREN Cases To Existing Types Of Crash Tests

Bridget O'Brien-Mitchell, Kacy Bailey, Daniel Faust, Jack Jensen, Julie Kleinert, Christine Wodzinski Stewart Wang
University of Michigan Program for Injury Research and Education, United States

Abstract:
A comparison of U-M CIREN (University of Michigan Crash Injury Research and Engineering Network) cases to crash tests used in the automotive industry is presented in this paper. 442 U-M CIREN crashes were compared to crash test configurations used throughout the industry. Of those 442 cases, 49% were similar in crash configuration and crash extent to industry crash tests. 32% of the cases were similar to one of the industry crash tests in configuration but had greater extent. 20% of the cases did not match any of the current industry crash tests. This analysis concluded that the majority of injuries in this study occurred in crash configurations similar to existing crash tests while only 20% of cases had crash configurations that were not represented by current crash tests. Any consideration of increasing test severity to address those crashes that produce a greater extent of crash deformation than that produced in crash tests must consider a broader spectrum of collisions including non-injury producing crashes. This analysis must be done in a way that does not increase the risk to the current uninjured population that is not included in the CIREN database.

Paper Number 09-0156-O

Priorities for Enhanced Side Impact Protection in Regulation 95 Compliant Cars

P. Thomas, Chair EEVC WG 21 Accident Studies
R. Welsh
Loughborough University, United Kingdom
E. Lenguerrand, G. Vallet
INRETS, France

Technical Session
Developments in Frontal/Side Impact Protection

D. Otte
Medical University of Hanover, Germany
J. Strandroth
Swedish Roads Administration, Sweden

Abstract:
This paper summarises the main results of an analysis of accident data conducted for the European Enhanced Vehicles Committee (EEVC) WG13 "Side Impact" to inform the further development of side impact test procedures for cars. The analysis of data from three countries was coordinated by EEVC WG 21 “Accident Studies”.
The national datasets of the UK, France and Sweden from the year 2005 were analysed containing a total of 411,311 cars. In each country side impacts typically represented 33% of all fatalities but less than 25% of casualties of all severities. Struck-side occupants represented typically 60% of all side impact casualties regardless of injury severity while the remainder of the casualties were seated away on the non-struck-side.
Amongst single vehicle side impacts, collisions with poles were most commonly specified, although there was considerable variation between countries. In multi-vehicle crashes the collision partner was a car in about 75% of cases. The relative involvement of each type of collision partner varied by casualty severity and in both the UK and France there were similar numbers of fatalities in collisions with poles as with cars. A comparison of injury risks suggested the risk of serious injury in newer cars struck by other newer cars was similar to older, pre-Regulation 95, cars struck by older cars. This indicates the improvements in side protection since the introduction of Regulation 95 may have been at least partially offset by increases in front stiffness of cars due to the introduction of Regulation 94 and EuroNCAP.
The paper presents other details on the circumstances of side impacts and the different driver populations involved in loss-of control and intersection collisions.
It links to two other papers concerning car-to-car and car-to-pole side collisions using in-depth data.

Paper Number 09-0096-O

Quantification Of The Scatterring Due To The Dummy Set-Up In Side Pole Impact

Céline Adalian, Nathalie Nowakowski, Richard Zeitouni
PSA Peugeot Citroën, France

Abstract:
Up to 2008, in the Euro NCAP rating, the assessment of the adult protection in pole test was only made through the head criteria. From 2009, the pole test in the new "overall rating" Euro NCAP protocol will take into accounts all body regions (head, chest, abdomen and pelvis). The aim of this study is to analyse the scatter of biomechanical criteria linked to these different body regions. Three phases were defined:
-Phase 1: analysis of a large number of pole tests in order to identify what body region was the most scattered.
-Phase 2: quantification of the scatter linked to the car, seat and dummy set-up. Ten trials of dummy set-up in three laboratories and on three types of vehicles were analysed. The first one of these trials was for reference, since it followed rigorously the vehicle and dummy set-up

protocols proposed by Euro NCAP. The other trials were made to assess the scattering by varying several parameters such as vehicle mass, type of dummy, operator. These trials gave us the maximum scattering that could exist and that can be reproduced in dynamic tests.
-Phase 3: quantification of the consequences of the dummy positioning on the pole test's dummy readings. Indeed, several pole tests will be carried out on identical vehicles with different dummy positioning. The results of this study will have to be linked to their consequences on the biomechanical criteria, in particular on the chest and abdomen. Recommendations are given to improve the dummy set-up procedure by taking into account these possible scattering of the dummy positioning and by proposing counter measure to avoid them in a future protocol.

Paper Number 09-0184-O

Lateral Glazing Characterization Under Head Impact: Experimental And Numerical Investigation

Marie Munsch, Nicolas Bourdet, Caroline Deck, Rémy Willinger
University of Strasbourg – IMFS-CNRS, France

Abstract:
In case of lateral impacts, the most frequent contact source is the side window. This window is also the most frequent aperture through which occupants are partially or fully ejected during a lateral crash. In order to keep occupant within the vehicle during a collision, laminated side glasses have been developed to gradually replace tempered glasses. Three-layered laminated glazing is composed of two glass layers separated by a plastic PolyVinylButyral (PVB) interlayer. The aim of the present work is to improve the understanding of the side window's mechanical behaviour during a head impact. An experimental study is undertaken which consists of an impact of a Hybrid III dummy head on both laminated and tempered side glazing. It appears that at same velocity, impact against laminated glass leads to a significant lower injury head risk than a tempered glass. The principal role of laminated glazing has been preserved as PVB layer never fails. A laminated side glass FE model is then proposed based on experimental validation, with the PVB interlayer implemented by an elastoplastic law with failure criteria. A parametric study is carried out to define the influence of the laminated glass mechanical characteristics on the head response. The parametric study pointed out the importance of the glass layer thickness on head responses in terms of head injury criteria.

Paper Number 09-0549-O

Results of NHTSA's Comparison of the Offset Deformable Barrier and the Progressive Deformable Barrier Test Procedures

James Saunders
National Highway Traffic Safety Administration, United States
Pascal Delannoy
Teuchos-Safran Group, UTAC Passive Safety Department

Abstract:

Technical Session
Developments in Frontal/Side Impact Protection

Over the past several years, NHTSA has conducted testing to evaluate a high-speed fixed offset deformable barrier crash test. It was preliminarily determined that the benefits from such a crash test could lead to an annual reduction in approximately 1,300 to 8,000 MAIS 2+ lower extremity injuries. NHTSA also conducted vehicle-to-vehicle crash tests to investigate the potential for disbenefits from a fixed offset deformable barrier crash test. This testing demonstrated that, for some sport utility vehicles, structural changes that improved their performance in high-speed frontal offset crash tests may also result in adverse effects on the occupants of their collision partners.
The Directorate for Road Traffic and Safety (DSCR) of France developed and proposed a Progressive Deformable Barrier test procedure (PDB) to upgrade the current offset deformable barrier test procedure in the United Nations Economic Commission for Europe (UNECE) R.94 regulation. DSCR is proposing the PDB to potentially improve the barrier performance in testing of the current and future fleet. Therefore, NHTSA is investigating the use of the PDB in the offset test procedure by comparing the current offset deformable barrier test procedure specified in FMVSS No. 208 (ODB) to the PDB. This paper also investigates the performance of each barrier to predict lower extremity injuries and the ability of the PDB to absorb more energy for heavy vehicles found in the United States (U.S.) fleet.
The PDB performed as designed for heavy vehicles and produced approximately the same occupant compartment intrusions. Both the ODB and PDB did not produce the same lower extremity injuries as seen in the real-world.
The general trend across each body region had a similar trend for each barrier. That is the magnitude of each IAV for each body region was approximately the same for each barrier, but one barrier is not always the maximum.

Paper Number 09-0105-O

Development Of A High Deceleration Full Width Frontal Impact Test For Europe

Mervyn Edwards
TRL, United Kingdom
On behalf of the APROSYS SP1.2 consortium

Abstract:
To assess a vehicle's frontal impact crashworthiness an integrated set of test procedures is required that assesses both the car's self and partner (compatibility) protection. It has been recommended by the International Harmonisation of Research Activities (IHRA) frontal impact group that the set of test procedures should contain both full overlap and offset tests. Currently, in Europe only an offset test is used in regulation and consumer testing. In 2007, the European Enhanced Vehicle-safety Committee (EEVC) made a number of proposals for a set of test procedures, all of which contain full width and offset tests.

This paper presents the work performed by the European Commission 6th framework APROSYS project to develop a full width test procedure for Europe. It also describes an initial cost benefit analysis for its introduction into the European regulatory regime.
Accident analysis was performed using the UK CCIS and German GIDAS databases to help determine the test speed, what size dummies should be used and the relevance of including

rear seated dummies in the test. A matrix of 12 full scale car crash tests was performed to determine the effect of including a deformable face, the effect of including rear seated occupants and to assess the test's repeatability and reproducibility. As all the tests were instrumented with a high resolution Load Cell Wall, the repeatability and reproducibility of proposed metrics to assess a car's compatibility were also assessed.

Paper Number 09-0203-O

Summary of Activities of the Compatibility Working Group in Japan

Hideki Yonezawa
National Traffic Safety and Environment Laboratory
Koji Mizuno
Nagoya University
Takahiro Hirasawa, Hitoshi Kanoshima
Ministry of Land, Infrastructure, Transport and Tourism
Hideaki Ichikawa, Shuji Yamada, Hideki Koga, Akira Yamaguchi
Japan Automobile Manufacture Association, Japan
Yuji Arai
Japan Automobile Research Institute, Japan
Atsumi Kikuchi
Institute for Traffic Accident Research and Data Analysis, Japan

Abstract:
In 2006, the Transport Policy Council's Report in Japan stated that it is necessary to discuss compatibility improvement considering the traffic accident environment in Japan. In response to this report, the MLIT has launched the Compatibility Working Group in Japan. This paper summarizes the activities of the WG toward the compatibility improvement.
In the WG, accident analyses and crash tests were performed to identify the safety problem. From global accident data, it is shown that as the front rail of the opposite (or collision partner) car was higher, the injury risk to the occupant tended to be higher. Full frontal car-to-car crash tests were conducted to investigate height matching and mismatching conditions of front rails. It was suggested that matching the front rail heights between two cars provides an overall safety benefit for occupant protection, though the leg injuries may became worse. From the accident analysis and crash tests, it was recognized in the WG that the matching of the front rail heights could be the first issue to be investigated for compatibility improvement.
To evaluate the height of front rails, geometrical measurements and analysis of crash test data can be considered. The footprint of the front rails can be observed in the measured barrier force distribution of a full-width rigid barrier test. Accordingly, to evaluate the front rail heights, measurement and evaluation of the barrier force distribution using high-resolution load cells in a full-width rigid barrier test was investigated. Several methods were developed and proposed for evaluating the front rail heights based on the barrier force distributions.

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Paper Number 09-0453-O

Reproducibility Of AHOF400 And KW400

Guy Nusholtz, Lan Xu, Edith Lugo Velez, Tim Hsu, Sadegh Babaii Kochekseraii
Chrysler LLC., United States

Abstract:
AHOF400 estimates the average height, from the ground, of the interacting force between a vehicle and the barrier in a rigid barrier crash test. Similarly, *KW400* estimates the "stiffness" derived from the force-crush relationship corresponding to a vehicle crashing into a ridge barrier. Both metrics are calculated during the first 400 mm of crush. Although, the formulas for calculating both *AHOF400 and KW400* appear simple, the reproducibility for these two measures has not been determined. One area of concern is variations in numerical methodology, signal processing algorithms and/or labs can lead to different results: numerical issues such as, determining time zero of a signal may increase lab to lab variability. In addition, AHOF400 and KW400 may not be the invariants of the system: they may be velocity dependent.

Paper Number 09-0022-O

Evaluating Vehicle Incompatibility Using Center of Velocity Change Methodology

Gowrishankar Srinivasan
URC Enterprises Inc,. United States
Joseph Kanianthra
National Highway Traffic Safety Administration (Now retired and a principal of Active Safety Engineering), United States

Abstract:
The concept of compatibility includes not only the safety of the occupants within the subject vehicle itself, but also the safety of occupants in other vehicles that are involved in the collision. The term self-protection describes the safety afforded to the occupants within a vehicle, while partner-protection describes the safety afforded to the occupants of the crash partner vehicle. Early research identified vehicle weight as having a critical but not exclusive role in defining crash outcomes. The geometry and vehicle stiffness or crush characteristics were also observed to play a significant role.

This study uses the New Car Assessment Program[1] (NCAP) frontal barrier test data to find a suitable metric to assess the effect of incompatibility in crashes involving light passenger vehicles. The number of drivers with AIS 3+ injuries in head on crashes between passenger car (PC) and light truck vehicle (LTV) is used to compute the effectiveness of the metric. NCAP crash test data for 239 vehicles were used in calculating the value of "distance from ground to the center of velocity change". Ten years of National Automotive Sampling System /crashworthiness data systems[2] (NASS/CDS) data were used to demonstrate the metric. The crash compatibility metric developed can be used to compare the number of injuries that result in PCs - LTVs head on crashes.

Most safety benefits can be achieved by changes in the metric, specifically, adjusting for vehicle size (height) and the structural characteristics (stiffness). Hence the metric can be used

as a measure of compatibility in crashes between vehicles.
This study is limited to investigation of incompatibility in full head-on crashes. This paper develops a new comprehensive metric that can quantify the compatibility disparity.

Paper Number 09-0380-O

Effects Of Active Structures On Injuries In Medium Severity Frontal Impacts

Bengt Pipkorn
Autoliv Research, Sweden
Anders Kullgren
Folksam Research and Department for Public Health Sciences, Karolinska Institutet, Sweden

Abstract:
An evaluation of the influence of crash pulse shape on the risk to sustain injuries in medium severity frontal collisions was carried out by reconstructing a number of real world accidents using mathematical simulations.
Ten crashes with restrained occupants, recorded crash pulses and known injury outcomes were selected for reconstruction. The crashes were selected from the Folksam accident database. Delta-V and mean acceleration were derived from the recorded crash pulses. The injury outcome was collected from hospital records and questionnaires and coded according to the 2005 version of AIS. Only restrained occupants were included. Computer simulations using a mathematical model of the 50%-ile Hybrid III dummy were used to evaluate the influence of the crash pulse on the loading of the occupants. The restraint system was a state of the art system with a driver side airbag and a belt system equipped with a pretensioner and a load limiter. Simulations were carried out in which the crash pulse shape was varied according to what can be achieved with the frontal longitudinal beam in which the crush force can be varied. Injury reducing benefits for the occupants were achieved by varying the crash pulse shape in medium severity impacts. The principal technical solution to vary the crash pulse is to pressurize the frontal longitudinal beams in the frontal structure prior to impact. In low and medium-speed impacts, the beams are not pressurized to use the available crush distance of the vehicle front. In high-speed impacts, the beams are pressurized to increase the force level of the beam and use the available crush distance of the vehicle front efficiently.

Paper 09-0248-O

Detailed Analysis Of Target Crashes For Pre-Crash Sensing Applications

Ana Maria Eigen
National Highway Traffic Safety Administration, United States
Wassim G. Najm
Volpe National Transportation System Center, United States

Abstract:
Target pre-crash scenarios, crash modes, and occupant injury mechanisms are statistically described for crash imminent braking (CIB) and advanced restraint system (ARS) applications

based on pre-crash sensing. Vehicle-object and vehicle-vehicle crashes are distinguished between single-impact and multiple-impact crashes. This analysis focuses on light vehicles of model year 1998 or higher that suffered frontal damage from the first most harmful event. An in-depth examination of candidate crash cases from target crashes was conducted to understand crash mechanisms and circumstances as well as occupant injury scenarios. Consideration was given to pre-crash conditions for CIB applications and to injury source for ARS applications. Results will be used in subsequent research to assess candidate CIB and ARS technologies, develop system functional requirements, devise test procedures, and estimate safety benefits.

Paper 09-0369-O

Investigation for New Side Impact Test Procedures in Japan

Hideki Yonezawa, Naruyuki Hosokawa, Yoshinori Tanaka, Yasuhiro Matsui
Shunsuke Takagi
National Traffic Safety and Environment Laboratory
Takahiro Hirasawa, Hitoshi Kanoshima
Ministry of Land, Infrastructure and Transport
Koji Mizuno
Nagoya University, Japan

Abstract
Side impact regulations have been introduced in many countries to improve occupant protection in side collisions. As a result, car structures have been improved significantly. However, the number of fatalities and serious injuries in side collisions is still large. To understand the causes of these injuries and to identify their potential countermeasures, accident analyses of side collisions were newly conducted.

From the accident data analysis, it was shown that the contacts with the head and chest during side crashes are still a major cause of serious injuries and death. The impact vehicle type affected the injured body regions of the occupant in the struck vehicle, and the chest was frequently injured in the struck car when impacted by an 1BOX type vehicle. Occupant seating postures were surveyed in vehicles on the roads, and it was found that from a side view that the head location of 50% of the drivers was in line or overlapped with the vehicle's B-pillar. This observation suggests that in side collisions head injuries may occur frequently due to contacts with the B-pillar.

A series of side impact tests were conducted to examine test procedures that would be beneficial for improving occupant protection. When the 1BOX was a striking vehicle, the chest deflection of the ES-2 dummy was large. The crash tests also included car-to-car crash tests in which either (1) both cars are moving or (2) one car is stationary, i.e., an ECE R95 test. The injury measures of the ES-2 dummy were substantially smaller if the struck car was moving.

The tests also were conducted for an occupant seating position where the head would make contact with the B-pillar. To investigate the effectiveness of curtain side airbags for head protection in car-to-car crashes, these test were conducted for struck cars with and without a

curtain side airbag. It was demonstrated that the curtain side airbag was effective for reducing the number of head injuries in car-to-car crashes.

Oral Presentations

Technical Session
Vehicle Stability and Control Systems, and Rollover Prevention

Oral Presentations | Tuesday, June 16th, 2009 | TRACK C | Room C7

Time: 09:00-12:30

Chairperson: Kyong Han Yoon, Korea
Co-Chairperson: Antonio Erario, Italy

Paper Number 09-0076-O

Impact Of Different Vehicle Models On Threat Assessment In Critical Curve Situations

Mohammad Ali
Volvo Car Corporation
Jonas Sjöberg
Chalmers University of Technology, Sweden

Abstract:
Curve speed warning systems (CSW) utilize information about the road and warn drivers if they are about to enter a curve too fast. Recent research shows that CSW is successful in warning for upcoming curves. However no statistically significant change in driver behaviour due to CSW has been shown. In addition, a common requirement cited by drivers is that the amount of false alarms needs to be reduced. This paper evaluates how the level of detail in the modelled vehicle dynamics influences the threat assessment in a situation with an oncoming curve. The point mass model that is commonly used by CSW is compared with more detailed models. Maximum velocity the vehicle can have while still following a curve is investigated and compared for the point mass model, the single track model and the double track model. It is shown that as the level of detail in the modelled dynamics increase, the maximum velocity profile is significantly reduced. This implies that in order to make a reliable threat assessment that can reduce the amount of false alarms and even be used as a base for an autonomous intervention, a more complex vehicle model than the point mass model is required.

Paper Number 09-0141-O

A Probabilistic Warning System For Safe Curve Negotiation

Guillaume Rey, David Clair, Michel Fogli
Laboratoire de Mécanique et Ingénierie (LaMI), France
Frédéric Bernardin
Laboratoire Régional des Ponts et Chaussées (LRPC), France

Abstract:

Technical Session
Vehicle Stability and Control Systems, and Rollover Prevention

While empirical evidence shows the main effects of the driving style (principally speed choices) on safety, this study aims to quantify the influent parameters and their interactions upon the roadway departure risk. A previous work [1] using a sensitivity analysis concludes that speed, lateral position on the pavement, total embedded mass and mass center position are the relevant parameters. They constitute what is called initial conditions in the following. Probabilistic methods for the risk assessment are proposed to deal with uncertainties arising from the road infrastructure, the vehicle characteristics and the driver behaviour. Those methods originally developed in the field of structural reliability reveal promising interest in the road safety question as they allow the direct computation of a risk index, not provided by a deterministic modeling. This approach involves both measurements on real traffic by static video sensors and simulations from a specifically developed model. A set of 400 experimental trajectories is used to define mean trajectories among different classes of drivers for one turn, and simulated ones are necessary for the reliability index calculation. The result of this study is a surface response of the roadway departure probability against initial speed and lateral position on the pavement. This work will lead to the development of a warning system within the French national project SARI. Envisaged alert procedures are warning light flashes inviting the driver to modify his trajectory if the risk index calculated at the entrance of the curve indicates a dangerous situation. Difficulty for short-term implementation comes from the statistical characterization of the initial conditions (i.e. mean value and standard deviation), especially for mass and mass centre position measurement device on standard vehicles.

Paper Number 09-0189-O

Validation Of Hardware In The Loop (HIL) Simulation For Use In Heavy Truck Stability Control System Effectiveness Research

Alrik L. Svenson Paul A. Grygier
National Highway Traffic Safety Administration, United States
M. Kamel Salaani
Transportation Research Center Inc.
Gary J. Heydinger
The Ohio State University United States

Abstract:
A Hardware in the Loop (HiL) system was developed to investigate heavy truck instability due to loss of control and rollover situations with and without ESC/RSC systems for a wide range of maneuvers and speeds. The purpose of this HiL model is to examine the safety benefits of the emerging electronic stability systems (ESC/RSC) in heavy trucks that are designed to prevent yaw instabilities (e.g., jackknife) and rollovers. This paper outlines the process for validating the HiL model so that the simulation closely represents the expected outcome for a similar maneuver conducted on a test track. The HiL system was built in a laboratory using the brake system of a truck and the actual stability control system control units supplied from a manufacturer. The dynamics software uses TruckSim, and the simulation results were validated using NHTSA collected field data. The HiL model is being used to examine yaw instability and rollover scenarios that would not be possible to conduct in actual track testing. Driving scenarios

were developed through an examination of Large Truck Crash CaUnited Statestion Study (LTCCS) cases. These scenarios were based on realistic events and were developed to replicate typical crash situations. The scenarios use a path-following driver model to drive through curves of various radii, a curve with a reduced radius, and variations of lane change maneuvers that are representative of obstacle avoidance. An overview of the scenario development, HiL system design, and the results of the validation of the HiL model are presented. The results of the validation show that the vehicle dynamics and hardware responses of the HiL are comparable to actual heavy truck test track results and can be helpful in determining the benefits of stability control technologies in varied driving situations.

Paper Number 09-0204-O

Enhanced Braking Performance By Integrated Abs And Semi-Active Damping Control

Marcus Reul, Hermann Winner
TU Darmstadt, Chair of Automotive Engineering, Germany

Abstract:
This paper is on focused on the optimization of the braking process integrating Antilock Braking System (ABS) and Continuous Damping Control (CDC). Strategies for reducing the braking distance derive from theoretical approaches. These strategies deal with sharing information between ABS and CDC in order to improve the slip-control quality and adjusting braking torque (ABS) and / or wheel load (CDC) coordinately. Quantities which influence the amount of the mean braking force and therefore the braking distance are identified methodically, regarding a standard control loop. Furthermore the influence of the time course of wheel load on the braking process is discussed. In the second section of this paper, experimental results of straight-line ABS-braking tests for two methodically identified strategies are discussed. The results of the first experiments show the influence of passive damper settings (hard, soft) and the Mini-Max damping control on the braking distance for various braking conditions (dry an wet roads, flat and unevenness roads,…). The MiniMax damping control aims for reduced body induced slip oscillations that usually disturb standard ABS-control. This damping control reduces the braking distance significantly in a statistical manner. The second experiment has been performed with a modified ABS which takes into account the information of the dynamic wheel load (due to pitching and lifting) additionally for the calculation of the braking force operation point. It is shown that the braking force operation point changes more, if dynamic wheel load information is implemented in ABS-control. Indeed the amount of modulated braking force operation point due to pitching or lifting is too small with respect to the demand, so further modifications are necessary. Finally an outlook on the next steps for improving the braking process by integrated ABS and Continuous Damping Control is given.

Paper Number 09-0209-O

An Analysis Of The Mechanism Causing Loss Of Control During A Tire Delamination

David Renfroe

Technical Session
Vehicle Stability and Control Systems, and Rollover Prevention

Alex Roberts
The Engineering Institute, United States

Abstract:
Electronic controls cannot always compensate for the destabilization of a poorly designed vehicle caused by tire delamination. Axle tramp caused from rubber strips on the track showed axle skate [1]. Further research, reported at ESV 2007 [2] demonstrated that lumps on a single rear tire caused 15+ degrees/g of oversteer.
The Engineering Institute has shown that the process of tire delamination causes some vehicles to become unstable at highway speeds. This was accomplished by actually preparing tires to partially delaminate while at 95 to 115 KPH on a remotely controlled vehicle. This testing demonstrated a severe loss of control as the tire was delaminating. The testing also showed that the predominate mechanism of control loss arises from the imbalance created during the delamination process.
A discussion of the testing illustrating accelerations on the rear axle as well as displacements of the shock absorbers will be used to illustrate the imbalance excitation and the tramping motion of the axle. Previous research indicated that the oversteer gradient during such an event to be between 15 and 20 degrees per g. This would then yield a critical speed of about 45 KPH. The testing illustrates how a vehicle loses control when the vehicle transitions from understeer to oversteer at highway speeds significantly above the critical speed from tire failure induced forces. Alternative suspensions were tested using the same simulated tire failure and illustrated how the vehicle stability is increased.
Using these results, a design criteria based upon a percentage of the critical rotational damping is proposed to control axle tramp from excitations at the harmonic frequency.

Paper Number 09-0278-O

ESC Standard Fitment And Failure To Protect Young Drivers

Alix Weekes, Matthew Avery
Thatcham, United Kingdom
Richard Frampton, Pete Thomas
Loughborough University, United Kingdom

Abstract:
The objective of the paper is to estimate UK fleet penetration of stability controlled vehicles, and casualty reduction, particularly for younger drivers. Two models (timeline 2003-2030) were developed for predicting UK fleet ESC penetration, one for Availability of ESC, and one for new car Registrations with ESC. Availability of standard ESC fitment increased from 40-53% from 20062008, whilst new car registrations increased from 20-56% from 2003-2008. EC regulation requires ESC new car penetration by 2014, and the models were modified to reflect this requirement. The models therefore project complete standard fitment in new cars by 2014, and full car stock penetration by 2021. The projections also reveal that another 3 million more new cars purchased without ESC in the interim from 2009 before ESC becomes mandatory in 2014,

and these cannot be retro-fitted with ESC so represent a missed opportunity for casualty reduction. ESC casualty reduction was calculated using recent effectiveness values from UK studies based on a case control method and induced exposure. With full fleet penetration in 2021 ESC is projected to prevent 9,587 casualties annually including 382 fatalities, with £764 million savings (compared to no ESC). ESC effectiveness estimates reveal that ESC could be effective in reducing 14% of injury crashes for young drivers. These young drivers commonly drive small used cars with ESC rarely fitted. Since full fleet penetration could take 12 years, faster ESC introduction into smaller cars is needed for casualty reduction amongst younger drivers who represent 30% serious injuries & fatalities. Providing ESC on smaller cars so that younger drivers are protected equates to savings of £227 million and 2,844 casualties annually.

Paper Number: 09-0284-O

Study Of Body Configuration And Superior Occupant protection During Rollover

Toshiaki Sakurai

Department of Mechanical Engineering, Iwaki Meisei University, Japan

Abstract:
This paper describes reconstructions of rollovers involved in the initial velocity before accidents are very important and the body structures of automotive vehicles with some curved configurations that have the incontestable superiority for occupant protection in rollover accidents over plain square body structures. The oval configuration and the curved structure are recommended. Furthermore, in a rotational movement system, acceleration force, inertia force and rotational moment of the vehicle to dummy should be considered as input forces.

Paper Number 09-0481-O

Car Rollover Mechanisms And Injury Outcome

Richard Cuerden, Rebecca Cookson, David Richards

TRL, United Kingdom

Abstract:
The study focused on the mechanisms which result in passenger cars over turning. Approximately 21% of the car occupant fatalities examined in the UK's Cooperative Crash Injury Study (CCIS) experienced a rollover. However rollovers are shown to be complex events, which can occur with or without impact(s) and are not always the principal cause of the resulting occupant injuries.
The study differentiates the different types of rollovers and presents the influencing factors which precede them. Rollover events are divided into three categories: simple rollovers which don't involve a significant impact; rollovers followed by impact(s); and impacts followed by rollovers.
The research correlated the cars' dynamic motion immediately prior to the initiation of the roll, the mechanisms which caused the car to roll and the consequences with respect to occupant injury. A significant proportion of the cars were identified as 'sliding' laterally to some degree prior to the roll and off-road soft surfaces such as grass or earth were the most frequent roll

initiators. Cars were also described as skidding or having lost control prior to leaving the road or striking a kerb or other roadside object or other vehicle. For this reason Electronic Stability Control (ESC) systems were identified as an important countermeasure with respect to potentially preventing a proportion of future rollover accidents.
Occupants, who were either fully or partially ejected from their cars, were strongly linked to severe injury outcome. Seat belts (ideally used in conjunction with other restraint devices designed to prevent either all or part of the occupants' body leaving the car through window apertures during the rollover) were shown to be effective.

Paper Number 09-0552-O

NHTSA's Class 8 Truck-Tractor Stability Control Test Track Effectiveness

Frank S. Barickman and Devin H. Elsasser
National Highway Traffic Safety Administration, United States
Heath Albrecht, Jason Church, and Guogang Xu
Transportation Research Center Inc. United States

Abstract:
Statistical analyses of crash data in the United States show that a large percentage of heavy truck crashes are rollover related. To evaluate roll stability for truck tractors, the National Highway Traffic Safety Administration (NHTSA) has performed test maneuvers with several Class 8 combination truck tractor/trailers on a test track. Stability Control interventions have been observed with all test track maneuvers conducted on dry pavement. Rollover events have been observed to be mitigated by stability control interventions in tests conducted with the truck tractor/trailer combinations loaded with a High Center of Gravity (CG) load.
This paper discusses the initial test track observations and test maneuvers NHTSA evaluated. Test maneuvers included constant radius increasing velocity tests, J-turn tests, and double lane change maneuvers. These tests were conducted with and without tractor and trailer stability control systems enabled. Tests were conducted under different loading conditions and on high coefficient of friction surface.

Oral Presentations

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

Oral Presentations | Tuesday, June 16th, 2009 | TRACK B | Room C5

Time: 14:00-17:30
Chairperson: Rodolfo Schöneburg, Germany
Co-Chairperson: Peter Robertson, Australia

Paper Number 09-0182-O

Unprecedented Vehicle And Traffic Safety Integrating V2X Communication

Dr.-Ing. Peter E. Rieth, Dipl.-Ing. James Remfrey
Continental AG, Division Chassis & Safety, Germany

Abstract:
Networking of active and passive safety systems is the fundamental basis for comprehensive vehicle safety. Situation-relevant information relating to driver reactions, vehicle behavior and nearfield traffic environment are fed into a crash probability calculator, which continually assesses the current crash risk and intervenes when necessary with appropriate measures to avoid a crash and reduce potential injuries. Know-how in the fields of active and passive safety, beam and image vehicle surrounding sensors, and innovative driver assistance systems provide effective protection not only for vehicle occupants but also for other, vulnerable road users. This functionality up till now only relates to the ego- vehicle itself. The next logical step is to integrate V2X communication. The integration of this embedded, in-vehicle wireless communication system allows Car-to-Car (C2C) and Car-to-Infrastructure (C2I) functionality for, e.g. time critical hazard warning. This comprehensive focus on creating cars that avoid crashes, prevent injuries and provide immediate assistance information should a crash prove unavoidable is an integral element of cascaded ContiGuard® protection measures.

Paper Number 09-0330-O

Using Dedicated Short Range Communications For Vehicle Safety Applications – The Next Generation Of Collision Avoidance

Arthur A. Carter
National Highway Traffic Safety Administration, United States
James Chang
Noblis, United States

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

Abstract:
This paper provides the status of the Vehicle Safety Communications-Applications (VSC-A) research project, which was designed to determine if dedicated short range communications (DSRC) paired with accurate vehicle positioning can improve upon autonomous vehicle-based safety systems or enable new communication-based safety applications. This three-year project is a collaborative effort between government and industry to develop the underlying pre-competitive elements needed to enable the deployment of vehicle-to-vehicle (V2V) communication-based crash avoidance applications. The effort includes the development of core software and hardware modules and prototype applications. These use DSRC in conjunction with enhancements to vehicle positioning systems to demonstrate crash avoidance capabilities, which are interoperable between different vehicle manufacturers. To support the development of interoperable systems, the partners have participated in standards and security protocol development activities. The core modules and prototype applications are implemented on a five-vehicle testbed fleet, which will be used to conduct objective tests that are then used to validate minimum performance specifications established as part of this project. These tests will in turn support a safety benefits estimation process to determine the potential for preventing or mitigating crashes and associated fatalities, injuries, and property damage.

Paper Number 09-0118-O

Cooperative Intersection Collision Avoidance System For Violations (CICAS-V) For Avoidance Of Violation-Based Intersection Crashes

Michael Maile, Luca Delgrossi
Mercedes-Benz Research & Development North America, Inc. United States

Abstract:
Intersection crashes account for 1.72 million crashes per year in the United States. In 2004 stop-sign and traffic signal violations accounted for approximately 302,000 crashes resulting in 163,000 functional life-years lost and $7.9 billion of economic loss [1]. The objective of the Cooperative Intersection Collision Avoidance System for Violations (CICAS-V) project was to design, develop, and test a prototype system to prevent crashes by predicting stop-sign and signal-controlled intersection violations and warning the violating driver. The intersection portion of the system consists of a signal controller capable of exporting signal phase and timing information, a local global positioning system (GPS), and Roadside Equipment (RSE) that includes computing, memory, and Dedicated Short Range Communication (DSRC) radio. The vehicle portion of the system includes onboard equipment for computing and 5.9 GHz DSRC radio connected to the vehicle controller area network (CAN), positioning, and the Driver-Vehicle Interface (DVI). The intersection sends the signal phase and timing, positioning corrections, and a small map (< 1 kb) to the vehicle. The vehicle receives this information and, based on speed and distance to the stop location, predicts whether or not the driver will violate. If a violation is predicted, the driver is warned via a visual/auditory/haptic brake pulse DVI. The system was installed in the vehicles of five Original Equipment Manufacturers (OEMs): Daimler, Ford, General Motors, Honda, and Toyota. Intersections were equipped in California, Michigan, and Virginia. Tests of the system included both on-road and test-track evaluations. System

performance was excellent and recommendations were made for continuing with a large field operational test (FOT). The system can be installed at any intersection with sufficient positioning coverage and in any vehicle with an electronic stability system. This system constitutes the first FOT-ready Vehicle Infrastructure Integration safety application

Paper Number 09-0193-O

Prediction Of Pre-Impact Occupant Kinematic Behavior Based On The Muscle Activity During Frontal Collision

Susumu Ejima, Yoshio Zama, Koshiro Ono
Japan Automobile Research Institute, Japan
Koji Kaneoka
Waseda University Faculty of Sports Sciences, Japan
Itsuo Shiina
Department of Orthopedic Surgery, University of Tsukuba, Japan
Hiroyuki Asada
Japan Automobile Manufacturing Association, Japan

Abstract:
The objective of this study is to predict the behaviors of the human body in pre-crash conditions based on the experiment with active human models. In order to simulate the actual pre-crash condition of a car that occurs when the drivers brakes or pre-crash safety system activates in an emergency situation, low speed front impact tests on human volunteers were conducted using a sled-mounted rigid seat, on which each subject sat, sliding backwards on the rails. It was observed that when the subject's muscles were initially relaxed, muscle responses started activation at around 100ms after the onset of acceleration and reached its maximum value at around 200ms. During this time period, most of the individual body region acceleration responses and restraint system reaction forces also peaked. Furthermore, the head-neck-torso kinematics was strongly influenced by the muscle activity. This experiment indicates that muscles can react quickly enough to control the driver's behavior significantly during the low-speed impact, relating to the driver's posture just before the collision. Thus, the active human model with the Hill-type multi-bar muscle was employed to estimate the possible driving posture in an emergency. From the result of this experiment, pre- and post- crash occupant behavior was predicted. For a more detailed understating, a parametric study was conducted that distinguishes the factors presented in real accident cases.

Paper Number 09-0419-O

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

The Effects Of Automatic Emergency Braking On Fatal And Serious Injuries

Maria Krafft, Anders Kullgren

Folksam Research

Anders Lie, Johan Strandroth

Swedish Road Administration, Sweden

Claes Tingvall

Swedish Road Administration, Sweden /Monash University Accident Research Centre, Australia

Abstract:

The introduction of automatic emergency braking changes the distribution of impact severity thus the resulting injury risk. In the calculation of the possible safety impact, risk functions must be used. These functions can be derived in different ways. In this paper, matched pair techniques have been used to study if the power models developed by Nilsson can be used. By applying the risk functions on theoretical changes of impact speed as a result of pre impact braking, the possible effectiveness on fatal and serious injuries can be estimated. It was found, that such braking can offer major benefits. A reduction of speed before impact with 10 % can reduce fatal injuries in car crashes with approximately 30 %.

Paper Number 09-0319-O

Usage of surround sensor information for passive safety – challenges and chances

Dr. Markus Könning, Dr. Thomas Heger

Robert Bosch GmbH, Germany

Abstract:

In this paper an approach of using surround sensor information for passive safety is being proposed. The combination of active and passive safety is necessary to reach the high aims to reduce the fatalities in road traffic up to 50% since 2000. Especially the surround sensor, like the video sensor, offers lots of information that can beneficially be used for advancing the current passive safety systems and design new functions that are not possible with current state of the art passive safety sensors. An overview about such possible passive safety functions is given with subject to the necessary sensor requirements. These requirements are derived among others from accident statistics and the required restraint system which should be activated. A major outcome of this evaluation, the different sensor requirements for comfort and safety functions, is presented. As an example for such kind of passive safety functions, the Video-supported pedestrian protection is presented with focus on reducing the crash severity by activation of a brake system and by supporting the current pedestrian protection system to pop up the hood by recognizing the pedestrians. As another example, Video-based PreSet and Video-based PreFire are presented with focus on protecting the occupant in the best way possible by an optimal choreography of the reversible and irreversible restraint systems. Therefore, the sensor characteristic must be slightly different and well designed to the special functional variant. In the end a first indication about the potential of such systems and a forecast

of future systems is given.

Paper Number 09-0534-O

Pre-Crash Phase Analysis Using A Driving Simulator. Influence Of Atypical Position On Injuries And Airbag Adaptation

Hault-Dubrulle Audrey, Robache Frédéric, Drazétic Pascal,
Morvan Hervé
Laboratory of Industrial and Human Automation, Mechanics and Computer Science, LAMIH, University of Valenciennes, France

Abstract:
This paper deals with an approach to analyze driver behavior during critical events using a driving simulator. A scenario of an unavoidable crash is simulated. Eighty subjects have participated to this experiment. Drivers' behavior is video recorded, as well as many mechanical and physiological measurements. Most of drivers are observed to swerve away to avoid the collision. This leads many of them to have one arm in front of the steering wheel at time of crash. The drivers' trunk and arm positions during the collision, observed on the simulator, are analyzed with numerical simulations of a 56 km/h frontal collision. The results of the computational runs put forward injurious situations, especially when the driver's arm is behind the steering wheel and hits the head under airbag deployment. Then, an experimental campaign of airbag deployment with a hybrid III 50th percentile dummy is carried out to correlate numerical simulations. Finally, new airbag generations, allowing slower deployment, are tested. They induce a reduction of injury severity in the case of Out of Position (OOP).

Paper Number 09-0333-O

The Effect Of Pre-Pretensioning In Multiple Impact Crashes

Ulrich Sander, Krystoffer Mroz, Ola Boström, Rikard Fredriksson
Autoliv Research, Sweden

Abstract:
German In-Depth Accident Study (GIDAS) data from 1999 to 2007 was compared to Hanover Medical School (MHH) data from 1973 to 1987 and it was found that the relative percentage of passenger cars sustaining more than one impact in a crash, so called multiple impact crashes, has increased by about one third within the last two decades. An analysis of 9316 GIDAS accidents from 1999 to 2007 showed a three-fold greater risk of severe injury and a four-fold greater risk of fatal injury for a multiple as opposed to a single impact crash. This study analyses multiple impact crashes in general and in particular occupant protection by out-of-position mitigation between impacts.
It was found that in two thirds of all multiple impacts with severe injury outcome, the irreversible restraint systems, front airbags and pretensioners, were not activated in an initial front impact. The corresponding proportion for non-activation of side and curtain airbags in initial side impacts was approximately fifty percent. To evaluate the risk of occupant out-of-position and the effect of one type of reversible system, a retractor pre-pretensioner, a finite element sled model including

the human body model THUMS, was used. In the simulation of initial front impacts with different changes of velocity, followed by a braking sequence, the pre-pretensioner leads to an obvious reduction in the forward chest displacement of the human model. Furthermore, depending on the pre-pretensioner force, the human model may be pulled back into its initial seating position. The calculated time distribution between initial and subsequent impacts with a median of 0.6 to 0.8 seconds, was used for the evaluation of "pre-crash" measures. The effectiveness of pre-pretensioning to position the occupant between impacts, ranges from 24% with 200N, to 93% with 400N pre-pretensioning force.

Paper Number 09-0165-O

The Mercedes-Benz Experimental Safety Vehicle 2009

Ulrich Mellinghoff, Prof. Dr. Thomas Breitling, Prof. Dr. Rodolfo Schöneburg, Hans-Georg Metzler
Daimler AG Mercedes Car Group, Germany

Abstract:
The way was paved for the first ESV Conference in the early 1970s by the development and discussion of what were called Experimental Safety Vehicles. From the outset, Mercedes-Benz played an active role in this initiative. Up until the mid-1970s, over 20 Mercedes-Benz ESFs (for Experimental Sicherheits Fahrzeug) were built and presented. This short period of time also witnessed the development of basic innovations, some of which represent crucial milestones for vehicle safety:
-Structural safety
-Anti-lock Braking System (ABS)
-Belt pre-tensioner and belt force limiter
-Airbags
-Side impact protection
-Electronic Stability Program (ESP)
-Partner Protection Systems
For the ESV Conference in 2009, Daimler is recreating this pioneering paradigm shift and developing a new Experimental Safety Vehicle, the ESF 2009. Based on the very latest safety features, such as Advanced Driver Assistance Systems, Adaptive Restraint Systems, and Integrated Safety Systems (PRE-SAFE®) [1], the ESF 2009 will present and demonstrate solutions for the requirements and safety challenges of the future.
This paper presents the safety features that Mercedes-Benz is focusing on to address vehicle and road safety requirements in the future.
In pursuit of our vision of accident-free driving and high-performance occupant safety, the paper looks at the following subjects and solutions, which could provide further sustainable advances in the field of vehicle safety:
-Systems for enhanced perception
-Vehicle communication
-Invisible protection zone
-Driver Assist Systems
-PRE-PULSE and innovative occupant protection systems

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

-Safety of alternative drive systems
The paper will describe functional models of the different safety features, their potential safety benefits, and feasibility requirements. The main goal of the Mercedes-Benz ESF 2009 is to illustrate mid and long-term safety features and to promote discussion on their relevance for achieving improved traffic safety.

Paper Number 09-0091-O

A Situation Based Method To Adapt The Vehicle Restraint System In Frontal Crashes To The Accident Scenario

Arno Eichberger, Daniel Wallner, Wolfgang Hirschberg
Graz University of Technology, Institute of Automotive Engineering, Austria
Robert Cresnik
Kompetenzzentrum – Das Virtuelle Fahrzeug Forschungsgesellschaft mbH (ViF), Austria

Abstract:
The integration of active and passive safety systems is considered as a significant contribution towards further improvement of traffic safety. The present article describes an approach to integrate these systems. This is done by development of a novel control algorithm where force levels and activation times of an assumed adaptive restraint system are predefined based on the oncoming collision. Reference values for these force levels are generated in order to minimise the acceleration of the occupants. The method takes into account the actual crash severity by a forecast of the acceleration behaviour of the passenger cell, based on prediction of collision speed, mass and stiffness of opponent and own vehicle. The prediction of mass and collision speed is not part of the present paper and currently under investigation. A forecast of the acceleration pulse is calculated by a simplified multi body model of the impact. The vehicle deformations are considered by non-linear springs with hysteresis. Their characteristics are derived from 53 crash tests published by NHTSA. The occupant of the ego-vehicle is considered also by a simplified multi body model, taking into account its mass and seating position. Optimisation algorithms determine suitable force levels and trigger times of the adaptive restraint components by minimising the acceleration of the occupant while avoiding bottoming-out of the restraint system. Currently, only straight frontal collisions with full overlap are considered. The algorithm is developed in order to provide a real-time application and is verified by detailed off-line crash simulations. With numerical simulations several configurations with different collision severities and occupant masses were investigated. In almost every configuration significant reductions up to 90 % of the occupant acceleration were observed. The present study forms the basis of future work which includes a real-time application in a vehicle.

Paper Number 09-0283-O

Powered Two Wheelers Integrated Safety – First Results Of The Sim Project

Mario Donato Santucci, Marco, Pieve
Piaggio & C. SpA, Italy

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

Jens, König
DEKRA Automobil GmbH, Germany
Elena, Bianco
Centro Ricerche Fiat, Italy
Jesús Vázquez de Prada Martinez
CIDAUT, Spain

Abstract:
First outcomes of activities carried out in Safety In Motion EU project are hereafter described. SIM Project is aimed at identifying a suitable and comprehensive safety strategy for powered-two wheel (PTW) vehicles, in order to avoid road accidents and/or mitigate their consequences.

Starting from the outcomes of previous accidentology activities an in-depth analysis was conducted focusing on the scenarios identified as the most frequent and dangerous for PTWs accidents. Significant accident parameters were identified and related values were analyzed. Also a technology evaluation based on state-of-the-art analysis as well as partners expertise was conducted and the effectiveness of potential benefits of safety systems was evaluated in reconstructed accident scenarios.

On such a basis a PTW safety strategy has been identified in all safety areas.
The active safety improvement is reached by actively controlling PTW stability and improving riding comfort (advanced braking and suspension systems).

In preventive safety area an HMI Information Management concept for motorbike was identified as the most effective solution for enhancing the PTW rider's awareness. Focusing on passive safety aspects, a frontal airbag fitted on motorcycle (aiming at protecting rider against the primary impact) and an inflatable wearable device (mainly for secondary impact) have been chosen to be tested either separately or jointly.

The following safety devices have been finally selected in order to be implemented and tested on vehicle prototypes:

-Active Brake System -Stability management by traction control -Semi-Active Suspension System -Frontal airbag -Inflatable wearable device -HMI Information management concept for motorBikes (IMB)
-Enhanced HMI (ergonomic handlebar controls, wireless communication, Head-Up Display)

An integral approach to PTW safety enhancement was adopted, since all the safety devices will be implemented and tested on the same vehicle platform, the innovative PTW tilting three-wheelers Piaggio MP3.

Paper Number: 09-0049-O

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

Enhanced Automatic Collision Notification System – Improved Rescue Care Due To Injury Prediction – First Field Experience

Stefan Rauscher, Georg Messner, Peter Baur
BMW Group Germany/United States
Jeffrey Augenstein, Kennerly Digges, Elana Perdeck
William Lehman Injury Research Center University of Miami, United States
George Bahouth
Pacific Institute for Research and Evaluation, United States
Oliver Pieske
Ludwig-Maximilians-Universität München, Germany

Abstract:
This paper summarizes the initial findings from a database of crashes that involved BMW's equipped with Automatic Crash Notification (ACN) Systems in the US and Germany. In addition, first field experiences with BMW's enhanced ACN systems are reported where vehicles not only provide an initial crash notification but also transmit data describing the nature and severity of the collision event. The benefits of such a system, including the rapid recognition of potentially injured occupants based on key characteristics of each crash, are explored.
Since 2006, nearly 14,000 BMW crashes have occurred in the US involving vehicles equipped with ACN or enhanced ACN technology. Of these, 70% of occupants indicate no injury to the TSP (Telematics Service Provider) operators, 20% indicate they are injured in some way and require help while 10% provide no verbal response to the TSP call-taker. An investigation of a subsample of crashes occurring in Florida suggests that no hospital transport was necessary for 81% of the calls where no voice response occurred. Although the majority of these cases require no further care, 19% of the no voice population was subsequently transported to a hospital or trauma center for additional care. This population of occupants could benefit from an automatic call for help to a Public Services Answering Point (PSAPcommonly known as 911) that includes an estimate of the likelihood of serious injuries.
To assist in identifying crashes with incapacitating injuries, the William Lehman Injury Research Center (WLIRC) in Miami, Florida and BMW have pioneered the development of an algorithm called URGENCY. This algorithm is based on US national crash statistics and BMW internal data. The injury prediction by URGENCY permits the transmission of the earliest and best information to the PSAP. We report early observations of injury severity and location for enhanced ACN equipped vehicle crashes occurring in the US and Germany.

Paper Number 09-0538-O

Combining CIREN and NASS-CDS Data to Predict Occupant Outcomes in Frontal Crashes

Matthew Craig Mark Scarboro
National Highway Traffic Safety Administration, United States
Carol Flannagan

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

University of Michigan Transportation Research Institute, United States

Abstract:
The National Highway Traffic Safety Administration's (NHTSA) Crash Injury Research and Engineering Network (CIREN) provides detailed outcome and patient care information for a sample of seriously injured case occupants involved in motor vehicle crashes. NHTSA's National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) provides a population-based sample of tow-away crashes that includes both non-injured and seriously injured occupants. This study combines the strengths of CIREN and NASS-CDS to produce predictive models that relate occupant and vehicle measures to treatment and occupant outcomes.
Qualifying frontal impact cases from CIREN involving seriously injured driver and/or front outboard passengers were used to evaluate the significance of the relationship between vehicle crash/occupant parameters and hospital treatment/outcome. A subset of CIREN cases where event data recorder (EDR) information was obtained was also analyzed. Regression analyses were done to assess the significance of predicted variables with regards to the outcomes of interest. Using significant predictors, a set of functions were developed that predict the probabilities of an occupant going to the intensive care unit (ICU), experiencing invasive surgery (OR) within 12 and 24 hours of the crash, or fatality given serious injury. NASS-CDS cases meeting the same CIREN crash and occupant inclusion criteria were used to establish the probability of serious injury given a qualifying frontal impact. This study has shown that the NASS-CDS-based probability of serious injury and the CIREN-based probability of seeing various outcomes given serious injury can be combined to form models that estimate the joint probability that a case occupant involved in a qualifying frontal crash would see an outcome of interest (ICU, OR, or fatality).

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

Oral Presentations | Tuesday, June 16th, 2009 | TRACK C | Room C7

Time: 14:00-17:30
Chairperson: Philippe Vezin, France
Co-Chairperson: Stephen Ridella, United States

Paper Number 09-0020-O

Evaluation Of The Ribeye Deflection Measurement System

Narayan Yoganandan and Frank A. Pintar
Medical College of Wisconsin Milwaukee, WI United States

Abstract:
The objective of the present study is to evaluate the RibEye system used to obtain deflections in impact-related tests. A description of the system is presented based on the specifications of the manufacturer. Evaluations included chest compression tests under varying loading condition: mid-sternum, offset, and diagonal loading. Accuracy assessment tests included: sternum-mounted, and rib-mounted LEDs with and without initial chest rotation about the z-axis, and indenter-mounted LEDs. These quasi-static tests were followed by pure and oblique pendulum tests to the thorax at velocities of 4.8 and 6.6 m/s. LEDs on the sternum responded similar to the available internal chest potentiometer. The accuracy of the system depended on positioning of the LEDs on the rib, magnitude of rib deformation, and potential interference from devices such as the presence of the internal chest potentiometer. Signal drop out depended on the type of indenter, with diagonal loading producing more signal loss. The deflection response along the x-and y-directions were deemed to be reasonable in oblique loading tests. Results from dynamic tests indicated that light interference from the internal component(s) restricts the ability of the system to obtain accurate deflections including signal drop out. In oblique tests, the system captured the asymmetric motions of the chest by demonstrating greater deflections on all left side ribs than right side ribs, thus showing its potential under this loading condition. The current fundamental evaluations helps in understanding of the performance of the system as installed in the midsize male Hybrid III dummy.

Paper Number 09-0437-O

Evaluation Of An Alternative Thorax Deflection Device In The SID-IIS ATD

Jack Jensen, Jeff Berliner, Barbara Bunn, Hollie Pietsch
Occupant Safety Research Partnership, United States
Dan Handman

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

Boxboro Systems, Inc.,United States.
Mike Salloum
Denton ATD, Inc., United States
Dominique Charlebois Suzanne Tylko
Transport Canada Canada

Abstract:
The use of a RibEye system in a SID-IIs crash dummy was evaluated. The SID-IIs is a small adult female side impact anthropomorphic test device. The RibEye is a non-contact optical system that uses triangulation to measure rib deflection.
This study quantified RibEye measurements using four evaluation environments. First, a SID-IIs thorax with an internal RibEye was impacted with a linear impactor and the measurements were compared to accelerometer and video measurements. Next, the RibEye was mounted in a vertical drop tower and impacted with a falling drop mass, simulating a purely lateral side impact. The RibEye measurements were compared to data from linear potentiometers, which are typically used in the SID-IIs. A similar drop tower test series was then conducted which included tests with the RibEye mounted at an angle to simulate oblique loading to a dummy during a side impact.
Lastly, a series of full vehicle crash tests were conducted to compare measurements from a SID-IIs dummy with a RibEye to a SID-IIs dummy with linear potentiometers.
The lateral drop tower tests indicated that peak deflections measured by the RibEye were generally within 1 mm of the linear potentiometer measurements. In the full vehicle crash tests, the RibEye and linear potentiometer measurements fell within the expected variability from crash test to crash test. User interface issues and the practicality of RibEye in the full vehicle tests are also discussed. In oblique loading tests, the RibEye revealed significant X-axis motions that cannot be measured by linear potentiometers as typically mounted in the SID-IIs thorax.

Paper Number 09-0418-O

Worldsid Small Female Two-Dimensional Chest Deflection Sensors And Sensitivity To Oblique Impact

Bernard Been and Kees Waagmeester
First Technology Safety System, The Netherlands
Xavier Trosseille
LAB PSA Peugeot Citroën RENAULT, France
Jolyon Carroll and David Hynd
TRL Ltd, United Kingdom

Abstract:
In the EC FP6 Integrated Project APROSYS, the first WorldSID small female prototype was developed and evaluated by BASt, FTSS, INRETS, TRL and UPM-INSIA. Results were presented at the ESV 2007 conference (Been *et al.*, 2007[1]). A concern was raised that the current chest deflection measurement system, IR-Traccs, registered flat top responses and

sometimes may not register the peak deflection. This was believed to be related to forward deformation of the ribs relative to the spine and associated extension of the IR-Traccs. In the mean time an update version of the dummy, called Revision1, was developed to address the issues found in the first evaluation round.
To improve oblique thorax loading sensitivity, a two-dimensional chest deflection sensor, the 2D IR-Tracc was developed. Measuring the angle between the spine box and the IR-Tracc enables the displacement of the most lateral point on the rib to be calculated in the XY (transverse) plane. To evaluate the new system, FTSS conducted single rib unit tests on a drop tower under pure lateral and oblique test conditions. The compression and rotation data were analysed to find the displacement of the most lateral part of the rib, and the rib deformation in the impact area. In addition, TRL subjected a complete Revision1 prototype dummy to oblique thorax pendulum tests and LAB conducted full dummy static deployment airbag tests under various impact angles and impact severities.
The 2D IR-Tracc proved to be very useful in understanding phenomena taking place under various lateral and oblique impact conditions that could not have been understood with the current (1D) compression sensor alone. The reduced sensitivity of the conventional IR-Tracc (Dy rib) to oblique impact was confirmed in this study. The calculated lateral displacement Y offered a simple and straightforward parameter to improve the sensitivity to oblique impacts, as compared to the current single axis deflection sensor.

Paper Number 09-0563-O

Comparison of WorldSID and ES-2RE Biofidelity Using an Updated Biofidelity Ranking System

Heather Rhule, Bruce Donnelly, Kevin Moorhouse
National Highway Traffic Safety Administration, United States
Jim Stricklin
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Abstract
In 2002 the biofidelity of the SID-HIII, ES-2 and prototype WorldSID side impact dummies were compared using a new Biofidelity Ranking System (BRS or BioRank) [Rhule, 2002]. The current study introduces updates made to the BRS and assesses the biofidelity of the ES-2re and the latest WorldSID side impact dummies. Approximately twelve drop tests, ninety pendulum tests and forty sled tests with a dualoccupant buck were performed with the ES-2re and WorldSID dummies, including lateral and oblique shoulder impactor tests [Bolte, 2003]; lateral and oblique thorax impactor tests [Shaw, 2006]; five Maltese sled tests [Maltese, 2002]; and several drop, pendulum and sled tests from ISO 9790 [ISO, 1999]. Test condition weight factors used previously have been eliminated in the updated BRS, giving all test conditions equal value. A scale for quality of the biofidelity ranking value, B, is demonstrated by comparing individual human subject responses to response targets and generating individual cadaver B values for both External and Internal Biofidelity. Having a scale of B values for the subject responses used to create the target response will give the user a metric for understanding the quality of a dummy's biofidelity. Finally, the sensitivity of the biofidelity

ranking value, B, is illustrated using data from repeated tests on multiple WorldSID dummies. The sensitivity analysis will help the user understand if the biofidelity of two (or more) dummies is similar or different. This recent data and updated BRS show that the WorldSID dummy exhibits improved overall biofidelity over the ES-2re. Results of the updated BRS show that the WorldSID and ES-2re demonstrated Internal Biofidelity values of 1.2 and 1.7, respectively; the WorldSID demonstrated an External Biofidelity score of 2.8.

Paper Number 09-0505-O

WorldSID Production Dummy Biomechanical Responses

Risa Scherer, Klaus Bortenschlager, Akihiko Akiyama, Suzanne Tylko, Markus Hartlieb, Takeshi Harigae
WorldSID Task Group

Abstract:
The results of biomechanical testing of the WorldSID production dummy are presented in this paper. The WorldSID dummy is a new, advanced **World**wide **S**ide **I**mpact **D**ummy that has the anthropometry of a mid-sized adult male. Based on previous testing the dummy design was frozen and developed into a production version of the WorldSID dummy. This dummy has been tested to determine that the biofidelity of the dummy has not degraded during its development and refinement.
The response corridors are defined in the International Organization of Standardization (ISO) Technical Report 9790. This dummy has been subjected to a rigorous program of testing to evaluate its biofidelity. The dummy's head, neck, thorax, abdomen and pelvis were evaluated against the ISO technical report requirements. Testing included drop tests, pendulum impacts, and sled tests. The biofidelity rating of the WorldSID was calculated using the weighted biomechanical test response procedure developed by ISO.
The WorldSID dummy has an overall ISO Biofidelity rating of 8.0, which corresponds to an ISO classification of "good". In addition the dummy shows good repeatability and good reproducibility. A comparison of the WorldSID dummy biofidelity compared to other existing side impact dummies biofidelity ratings will also be provided.

Paper Number 09-0263-O

Head And Spinal Trajectories In Children And Adults Exposed To Low Speed Frontal Acceleration

Sriram Balasubramanian, PhD, Thomas Seacrist, MS
Matthew R. Maltese, Kristy B. Arbogast, PhD
Center for Injury Research and Prevention The Children's Hospital of Philadelphia, United States
Terrance Hopely, BS, Eric Constans, PhD
Department of Mechanical Engineering Rowan University, United States
Robert Sterner, PhD

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

Department of Health and Exercise Science Rowan University, United States
Hiromasa Tanji, Kazuo Higuchi
Takata Corporation, Japan

Abstract:
Head injuries are the most common injuries sustained by children in motor vehicle crashes. Prevention of these injuries through advances in vehicles and restraint systems requires a biofidelic anthropomorphic test device (ATD). Pediatric ATDs are primarily developed from scaling down adult volunteer and cadaver impact test data. Limited experimental data exist on pediatric head and neck kinematics in order to evaluate the biofidelity of the ATDs. The aim of the current study was to evaluate the head and spinal kinematics of pediatric and adult volunteers in response to a dynamic low-speed frontal sled test. Low speed volunteer testing of five male subjects in each of two specific age groups (912, and 18-30 years) were performed using a pneumatically actuated – hydraulically controlled sled. Safe limits were established from measurement of bumper car accelerations at an amusement park ride (4.9 *g*, 55.7 msec rise time, 110 msec duration), which we believed to be sub-injurious to the adult and child amusement park population. We subsequently recreated the bumper car environment in the laboratory, by developing a low-speed hydro-pneumatic sled. As an added measure of safety, our average maximum cart acceleration was 3.59 *g* for children and 3.78 *g* for adults, thus producing occupant loads that are approximately 25% less than the bumper car amusement park ride. Spherical reflective markers were placed on the head, neck, torso, upper and lower extremities and tracked using a 3D motion analysis system. An angular rate sensor was mounted to a bite plate of an athletic mouth guard to measure the head rotational velocity. Electromyography sensors were attached to key muscle groups to measure the muscle response of the subjects to the loading environment. Each subject was subjected to six sled runs. Head and neck trajectories were compared between the adult and pediatric subjects. In addition, the effect of habituation on kinematic response was examined by comparing within subject changes in kinematics throughout the series of six sled runs.

Paper Number 09-0142-O

Comparison Of Passive Cervical Spine Flexion In Children And Adults

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Jami Saffioti, MS Jennifer Kadlowec, PhD
Department of Mechanical Engineering Rowan University, United States

Abstract:
Head trauma is the most frequent injury sustained by children in car crashes, and the neck

plays a key role in governing head kinematics during the crash. Pediatric anthropomorphic test devices (ATDs) are used to assess the risk of head injury, yet the pediatric ATD neck is a size-scaled model of the adult ATD neck, with no consideration for the tissue properties and morphological changes during human development. To help understand the effects of maturation on the changes in neck flexion biomechanics, this study compared the passive cervical spine flexion of children to adults in specific age groups (6-8, 9-12, 20-29, 30-40 years). Subjects with restrained torsos and lower extremities were exposed to a 1g inertial load in the posterior-toanterior direction, such that the head-neck complex flexed when the subject relaxed their neck musculature. Surface electromyography with audio feedback was used to coach the subjects to relax their neck musculature. A multicamera 3-D target tracking system was employed to capture the motion of specific landmarks on the head (Frankfort Plane) and thoracic spine (T1 and T4). Neck flexion angle with muscles relaxed was calculated for each subject. Neck flexion angle significantly decreased with age, with changes in head-to-neck girth ratio partially explaining the decrease. A statistically significant increase in cervical spine flexion was found in adult females compared to adult males. Data also illustrate this trend in children, but it was not statistically significant. In summary, these results demonstrate an increased passive cervical spine flexion in children compared to adults, and females compared to males. These data will help guide the development and validation of pediatric ATDs.

Paper Number 09-0154-O

Investigation Of Facet Joint Response Under Rear Impact Conditions Using FE Model Of The Cervical Spine

Jason B. Fice, Duane S. Cronin
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Matthew B. Panzer
Duke University,United States

Abstract:
Whiplash injury resulting from rear impact is a significant issue in terms of societal cost, and the resulting pain and reduction in quality of life. The facet joints in the cervical spine have been identified as a source of pain in whiplash injuries; however, the responses of these joints are difficult to measure in vivo or in vitro. In this study, a detailed explicit FE model of the cervical spine was used to investigate facet joint response under rear impact loading conditions. The model represents a mid-size male with detailed vertebrae, discs, ligaments and Hill-type active muscles. This model was previously validated extensively at the segment level and validated for frontal impact scenarios. In this study, the cervical spine model was validated against rear impact volunteer and cadaver tests (13 volunteers exposed to 28 rear impacts at speeds of 5 to 7kph; 26 cadavers exposed to rear impacts at speeds of 5 to 15.5kph) using experimental acceleration, displacement and rotation traces of the T1. Capsular ligament (CL) strains were measured in the model and compared to values presented in the literature to identify pain or sub-catastrophic failure. Simulation of 4, 7, and 10g rear impacts showed good agreement with the experimental data. The predicted CL strains were below or near the approximate threshold for pain and sub-catastrophic damage (35% strain), and exceeded this value for a 12g rear

impact case. This study included muscle activation, and provides a link between published strain limits for facet joint capsules evaluated in controlled lab conditions and strains predicted under rear impact loadings.

Paper Number 09-0412-O

A Global Head Neck Torso Model For Whiplash Injury Criteria Investigation

Nicolas Bourdet, Rémy Willinger
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Abstract:
The development of new protective systems must be performed on tools reliable and representative of alive human. In an earlier study, a simplified but realistic modeling of the head-neck-torso system under moderate rear impact was performed. This model of minimum complexity (MC-HNT model) but able to reproduce the 5 first experimental vibration modes was validated in the frequency domain in terms of natural frequencies and damping as well as mode shapes. The human model was then coupled to a car seat-head rest complex on Madymo Code in order to give real body behaviors and accurate T1 accelerations. The hypothesis of linear behavior was used for the torso being subjected to small deformations. The present study shows in detail the methodology carried out for real-world rear impact accident reconstruction in order to establish more accurate neck injury criteria as well as associated tolerance limits. In order to proceed to that, 87 accident cases were simulated using our MC-HNT human body model coupled to 3 Toyota seats under Madymo code. Several injury criteria, such as Neck Fx, Neck Fz, T1 acceleration, NICmax, Nkm and NDC, were calculated in order to correlate the risk of AIS1 neck injury using MCHNT. A similar work has then been done with the BioRID II model. Then a comparison between the predictive risk curves obtained by analyzing the MC-HNT model and the BioRID II model has been performed. This comparison was expressed in terms of Nagelkerke *R-square* values obtained with these analyses. It appears that the MC-HNT model gives a higher correlation than the BioRID II one for all parameter, and that the lower neck axial force is shown as the best candidate to correlate with the neck injury.

Paper Number 09-0384-O

Coupling Of Strasbourg University Head Model To Thums Human Body Fe Model: Validation And Application To Automotive Safety

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Abstract:
Human body segments and whole body models are more and more used in automotive safety research. Detailed in deep validated segmental models exist and are used for the definition of

improved injury criteria, transforming the models into injury prediction tools. The present collaborative work's objective is to couple and to validate the Strasbourg University Head FE Model (SUFEHM) with the THUMS human body model under Ls-Dyna code before applying the new tool under accidental environment.

In a first effort, Strasbourg University Head Model and related injury criteria developed in earlier studies under RADIOSS code had to be transferred under Ls-Dyna code, both at constitutive laws and injury criteria definition level. For this, a validation of the SUFEHM against Nahum and Yoganandan's experiments in order to validate brain and skull behavior respectively under Ls-Dyna has been done. After these validations the reconstruction of 59 real world head trauma has been conducted in order to propose head tolerance limits to specific injuries under Ls-Dyna code.

After this, the SUFEHM was coupled to the THUMS neck in order to create a hybrid "THUMS-Strasbourg head" model. At geometrical level the coupling was performed by creating interfaces at bone contact level and connecting ligaments and soft tissue elements to the head model. At mechanical level the coupled FEMs was validated under front, lateral and oblique impact regarding head-neck kinematics superimposed to experimental data.
This coupled model constitutes an original research tool for further investigation on the importance of human head boundary condition in case of head impact, whatever the accident condition are, car occupant, pedestrian or even motorcyclists.

Paper Number 09-0111-O

Development Of Next Generation Human Fe Model Capable Of Organ Injury Prediction

Kenji Shigeta, Yuichi Kitagawa, Tsuyoshi Yasuki
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Abstract:
Although internal organ injury in car crashes occurs at a relatively lower frequency compared to bone fracture, it tends to be ranked higher in terms of injury severity. A generalized injury risk can be assessed in car crash tests by evaluating abdominal force and viscous criterion (VC) using a crash test dummy, but the injury risk to each organ cannot be estimated with current dummies due to a lack of parts representing the internal organs. Recently, human body modeling research has been conducted introducing organ parts. It is still a challenge to simulate the impact behavior of organ parts and their injury, based on an understanding of the differences in structure and material properties among the organs. In this study, a next generation human body FE model has been developed to predict internal organ injury. The model represents the geometry of organ parts, their location in a living human body and their connections to surrounding tissues. The features of each organ part were taken into account in modeling, so that compressive material was assumed for hollow organs while incompressive material was applied to solid organs. Besides the major organ parts, other soft tissues such as membranes and fatty tissues were also incorporated in order to simulate relative motions among organs. The entire model was examined comparing its mechanical response to that in

the literature. The study confirmed that the force-deformation response of the torso against anterior loading showed a good correlation with that of tested subjects.

Paper Number 09-0508-O

Load Transfer and Deformation Characteristics of the Pelvis in Non-destructive Side Impact Testing

Andrew Kemper, Craig McNally, and Stefan Duma
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Abstract:
Although finite element models of the human body are becoming an integral tool in the reduction of automobile related injuries, these models must be locally and globally validated to be considered accurate. Therefore, the purpose of this study was to quantify the load transfer and deformation characteristics of the pelvis in side impact loading. A total of ten nondestructive side impact tests were performed on two human male cadavers. Three impact areas and two impacting surfaces were evaluated using a 16 kg pneumatic impactor at approximately 3 m/s: rigid-impact to the ilium, rigid-impact to the greater trochanter, rigid-impact to the ilium and greater trochanter, and foam-impact to the ilum and greater trochanter. Additional rigid-impacts to the ilum and greater trochanter were performed on one cadaver at 4 m/s and 5 m/s to evaluate the effect of loading rate. Load transfer through the pelvis was quantified by implanting custom *in situ* pelvic load cells in the ilio-sacral joint and pubic symphysis joint. In addition, strain gages were applied to the iliac wing, superior pubic ramus, ischium, and femur. The results showed that for all test conditions, except the rigid-impact to the iliac crest, a larger percentage of impactor force was transferred through the pubic symphysis joint than the ilio-sacral joint. The strain gage data showed that for all test conditions except one, ilium only impact, the superior pubic ramus and ischium were placed in compression. Conversely, the primary loading mode for the ilium 1st principle strain was tension for all test conditions. Impact speed was not found to have a considerable affect on the distribution of load through the pelvis. It is anticipated that this research will further the understanding of the biomechanical response of the human pelvis in side impact loading, and aid in the development and validation of computational models.

Paper 09-0306-O

Development Of New Criteria For Assessing The Risk Of Knee-Thigh-Hip Injury In Frontal Impacts Using Hybrid Iii Femur Force Measurements

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Carl S. Miller, Nathaniel H. Madura

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

University of Michigan Transportation Research Institute (UMTRI), United States
Kathleen D. Klinich, Shashi M. Kuppa
National Highway Traffic Safety Administration, United States
Lawrence W. Schneider
University of Michigan Transportation Research Institute (UMTRI)/ The University Michigan, Department of Biomedical, United States

Abstract:
Injury patterns in real-world frontal crashes and the forces predicted in computational simulations of knee impacts suggest that the risk of hip injury is higher than the risk of knee/distal femur injury in most frontal crashes that are similar in severity to those used in FMVSS 208 and NCAP. However, the knee-thigh-hip (KTH) injury criterion that is currently used with Hybrid III femur forces in FMVSS 208 and NCAP only assesses the risk of knee/distal femur injury.
As a first step to developing new KTH injury assessment criteria that apply to hip and knee/distal femur injury, a one-dimensional lumped-parameter model of the Hybrid III ATD was developed and validated. Simulations were performed with this model and a previously validated lumped-parameter model of the cadaver to explore relationships between peak force at the Hybrid III femur load cell and peak force at the cadaver hip over the range of knee-loading conditions that occur in FMVSS 208 and NCAP crash tests. Results of these simulations indicate that there is not a singular relationship between peak Hybrid III femur force and peak force at the cadaver hip or at the knee/distal femur.
Because of the complex relationship between femur force measured in the Hybrid III femur load cells and forces and injury risks in the human KTH, a new injury assessment criterion has been developed for the KTH that uses peak force and impulse calculated from force histories measured by the Hybrid III load cell to determine if the probability of KTH injury exceeds a specified value. The use of impulse allows the new injury assessment criterion to identify the high-rate, short duration loading conditions that are likely to produce knee/distal femur fractures and the slower loading rates and longer durations that are more likely to produce hip fracture/dislocation.

Paper Number 09-0196-O

Application And Evaluation Of A Novel KTH Injury Criterion For The Hybrid III Dummy In Frontal Crash Test Environments

Kristin Kirk , Shashi Kuppa
National Highway Traffic Safety Administration, United States

Abstract:
This paper evaluates a recently published comprehensive knee-thigh-hip (KTH) injury criterion through its application to the Hybrid III 50th percentile male (HIII-50M) and 5th percentile female (HIII-5F) dummies in frontal crash tests along with a comparison with real world KTH injury risk in frontal crashes. This criterion, developed by Rupp et al. (2009) (Rupp-KTH criterion), determines risk of injury to the hip, femur, and knee using the peak compressive femur force

and impulse.

Femur load cell data from various frontal crash tests were analyzed using the Rupp-KTH criterion. The risk of KTH injuries as calculated with this criterion in the various crash conditions was compared to that observed in real world frontal crashes using the National Automotive Sampling System-Crashworthiness Data Systems (NASS-CDS) data files. The relative proportion of knee, thigh, and hip injuries predicted by the Rupp-KTH criterion was also compared to that observed in real world crashes.

The Rupp-KTH criterion predicts an overall KTH injury risk reflective of real world risk with unbelted Hybrid III dummies, but under-predicts real world injury risk for belted dummies. The proportion of hip injuries among all KTH injuries is predicted reasonably well for unbelted occupants and under-predicted for belted occupants. Dummy interaction with the knee bolster in different restraint conditions likely affects the level of agreement between predicted and observed injury risk.

This study applied injury criteria to Hybrid III dummy responses in specific crash conditions and seating configurations. Injury risk prediction may be improved with other dummy designs or crash environments.

Oral Presentations

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Oral Presentations | Wednesday, June 17th, 2009 | TRACK A | Room C4

Time: 09:00-12:30

Chairperson: Anders Lie, Sweden
Co-Chairperson: Andre Seeck, Germany

Paper Number 09-0025-O

Development Of A Safety Impact Estimation Tool For Advanced Safety Technologies

Hirofumi Aoki, Masami Aga, Yoshiki Miichi, Yoshiaki Matsuo
Toyota Motor Corporation, Japan

Abstract:
In order to develop and deploy advanced safety technologies, it is important to estimate effectiveness based on the system function or performance. Although various types of safety impact methodology (SIM) have been proposed to date, few SIMs can be applicable for actual system effectiveness estimation. In this study, a universal SIM (T-SIM) was developed and its validity was confirmed against field data. T-SIM uses the number of fatalities and casualties (fatal and nonfatal injury) that are expected to be prevented by the technologies rather than just collision/avoidance ratio because some of the safety technologies, such as a collision mitigation system, can reduce the impact speed by brake application and thus may help reduce the number of fatalities and casualties. T-SIM consists of two parts: (1) accident pattern classification and (2) effectiveness estimation for each system. In the first part of the T-SIM, accident data from the National Automotive Sampling System - General Estimates System (NASS-GES) and Fatality Analysis Reporting System (FARS) were categorized by such variables as type of accident (e.g., head-on) and relation to the intersection. The categorized accident patterns enable users to choose the accidents for which the technologies may be effective. By using the same accident pattern database, users also can compare the effectiveness of different safety systems. In the second part of the T-SIM, accident patterns applicable to a particular safety system are selected from the categorized patterns. A driver-model and a vehicle-model can be applied, which allows users to examine the effect of system parameters and configurations. Through the validation process using a Electronic Stability Control (ESC) system as an example of advanced safety technologies, the estimated effectiveness by T-SIM was compared with that reported by a study based on field data [2]. Although the accident databases are different, statistical analysis showed the effectiveness

estimated by T-SIM is not significantly different from that by the field study and it was confirmed that the T-SIM can be used to estimate the effectiveness of other advanced safety technologies. Then the T-SIM was applied for a Pre-Collision System for the effectiveness estimation and further improvement. It was estimated that a PCS has high potential for reducing fatalities and casualties of rear-end accidents. In addition, it was also estimated that the PCS could be improved by changing such system parameters as warning, brake-assist and automatic brake timings.

Paper Number 09-0281-O

New Approach Of Accident Benefit Analysis For Rear End Collision Avoidance And Mitigation Systems

Andreas Georgi, Marc Zimmermann, Thomas Lich, Lisa Blank, Dr. Nils Kickler, Dr. Reiner Marchthaler
Robert Bosch Corporation, Stuttgart Germany

Abstract:
In Germany approximately 12% of all accidents with persons injured and approximately 20% of all material damage accidents are caused by cars in rear end collisions. As a consequence, Bosch is introducing collision avoidance and mitigation systems for rear impact scenarios. Warning, brake support, and autonomous emergency braking are part of Bosch's Advanced Emergency Braking Systems which address such accidents. This study determines the benefit of these assistance and safety systems and estimates the collision avoidance capability considering the driver's behavior. By analyzing representative accidents with injuries from the GIDAS (German In-Depth Accident Study) database, a high potential for collision warning and avoidance systems was determined. For the first time in such a study, this analysis considers the effects of different driver reactions due to warning, braking support, or autonomous braking with respect to the possible driver behavior. For this, a calculation method was developed and used for evaluating the accidents automatically. Both accident avoidance and average speed reduction was determined for different driver types, warning strategies and applications. From the results, an avoidance ratio of 38% for Predictive Collision Warning up to 72% for Automatic Emergency Braking, of all rear-end accidents can be expected for a realistic driver. Therefore it is estimated that 3 out of 4 accidents with severe injuries could be avoided based on the Emergency Brake Assist function and assuming a 100% installation rate. The potential to reduce collision speed in non avoided accidents is calculated on an average basis and is determined to be between 25% and 55% for the realistic driver. The results in the analyses show the high efficiency of the Bosch AEBS functions in avoiding accidents or mitigating injuries by reducing collision speed and should encourage the introduction of Advanced Emergency Braking Systems across a wide range.

Paper Number 09-0408-O

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Increased Safety And Reduction Of Congestion By Using Driver Assistance Technology; Dream Or Reality?

Margriet van Schijndel - de Nooij, Ard de Ruiter, Sven Jansen
TNO Automotive, The Netherlands

Abstract:
As accidents with trucks have a large influence on traffic flow, a large pilot on the effect of driver assistance systems was kicked off in July 2008 in the Netherlands. The primary goals of the pilot are to assess the potential for improving safety and maintaining traffic flow. The potential contribution of driver assistance systems to these objectives will be determined with 2550 trucks from about 100 transport companies. Each truck is equipped with one assistance system and a registration unit for monitoring driving and vehicle behaviour.
Driver assistance systems used are: Lane Departure Warning, Forward Collision Warning, Directional Control, Adaptive Cruise Control, Rollover Control and Black Box with Feedback. The latter system was developed especially for this project. Based on continuous measurements, the driver receives a daily report on his “safe and congestion preventing” driving behaviour. So far, drivers and transport companies are very positive on this system.
When closing the pilot halfway 2009, it will be concluded what the effects are of these systems on traffic safety and congestion. The conclusions will be based on proving ground tests, simulations and measurements from the pilot, like:
-Average speed, speed variations, accelerations, etc.
-Time-to-Collision over a time span, headway (time)
-Warnings and actions by the systems Effects on traffic flow will be quantified based on changes in driving behaviour and based on expected reductions of accidents. This pilot will deliver unique, statistical data on the actual effectiveness of a range of driver assistance systems.
The project is performed in a close cooperation between TNO, the Dutch Ministry of Transport, Public Works and Water Management, Connekt and Buck Consultants. Currently, the focus is on the Netherlands, but it is investigated how to interpret the results for Europe.

Paper Number 09-0148-O

Reconsidering Accident CaUnited Statestion Analysis And Evaluating The Safety Benefits Of Technologies: Final Results Of The Trace Project

Yves, Page
RENAULT
Thierry Hermitte, Cyril Chauvel
LAB
Pierre Van Elslande
INRETS, France
Julian Hill, Alan Kirk

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

VSRC Loughborough University, United Kingdom
Heinz Hautzinger
IVT
Sylvia Schick, Wolfram Hell
LMU, Germany
Kosmas Alexopolous, Menelaos Pappas
LMS, Greece
Aquilino Molinero, Jose Miguel Perandones
CIDAUT
Jose Manuel Barrios
IDIADA, Spain

Abstract:
The objectives of the EU-funded project TRACE (TRaffic Accident CaUnited Statestion in Europe, 2006-2008) are the up-dating of the etiology of road accidents and the assessment of the safety benefits of promising technology-based solutions. The analyses are based on available, reliable and accessible existing databases (access to which has been greatly facilitated by a number of partners highly experienced in safety analysis, coming from 8 different countries and having access to different kinds of databases, in-depth or regional or national statistics in their own country). Apart from considerable improvements in the methodologies applicable to accident research in the field of human factors, statistics and epidemiology, allowing a better understanding of the crash generating issues, the TRACE project quantified the expected safety benefits for existing and future safety applications. As for existing safety functions or safety packages, the main striking results show that any increment of a passive or active safety function selected in this project produces additional safety benefits. In general, the safety gains are even higher for higher injury severity levels. For example, if all cars were Euro NCAP five stars and fitted with EBA and ESC, compared to four stars without ESC and EBA, injury accidents would be reduced by 47%, all injuries would be mitigated by 68% and severe + fatal injuries by 70%. As for future advanced safety functions, TRACE investigated 19 safety systems. The results show that the greatest additional safety gains potential are expected from intelligent speed adaptation systems, automatic crash notification systems, and collision warning and collision avoidance systems. Their expected benefits (expected reduction in the total number of injured persons if the fleet is 100% equipped) are between 6% and 11%. Safety benefits of other systems are more often below 5%. Some systems have a very low expected safety benefit (around or less than 1%).

Paper Number 09-0317-O

Benefit Estimation Of Advanced Driver Assistance Systems For Cars Derived From Real-Life Accidents

Matthias Kuehn, Thomas Hummel, Jenoe Bende
German Insurers Accident Research, Germany

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Abstract:
Advanced Driver Assistance Systems (ADAS) are today becoming increasingly common in the market. The safety potential of these systems has been evaluated using different approaches in several studies. In order to quantify the effects of ADAS on accidents described by insurers` claim files, German Insurers Accident Research has performed a comprehensive study. The database used for the study was a representative excerpt from the German Insurers' data, covering 2,025 accidents. Statistical methods were used to extrapolate these accidents up to 167,699 claims.

The conclusions of the analyses are as follows: a Collision Mitigation Braking System (CMBS) which is able to gather information from the environment, to warn the driver and to perform a partial braking maneuver autonomously (CMBS 2), could prevent up to 17.8 % of all car accidents with personal injuries in the data sample. The theoretical safety potential of a Lateral Guidance System, consisting of Lane Change Assist and Lane Keeping Assist, was determined to be up to 7.3 %.

Hence, a car fleet equipped with CMBS 2 and Lateral Guidance could avoid up to 25.1 % of all car accidents in the data sample. This theoretical safety potential is based on the assumptions that 100 % of the car fleet is equipped with these systems and the driver reacts perfectly when warned.

Paper Number 09-0153-O

Situation-Interpretation As A Key Enabler For Cost-Effective And Low-Risk Driver Assistance Systems With High Collision Mitigation Capabilities

Jürgen Häring, Ulf Wilhelm
Robert Bosch GmbH, Automotive Electronics, Driver Assistance Systems (CC-DA/ESR4)

Abstract:
In the area of safety oriented driver assistance systems there is a trend to increase the accident mitigation capabilities by adding or strengthening autonomous system reactions. However, this also increases the potential for involuntary accidents in the case of malfunction. Due to product liability regulations these high risk functions require an increased development effort as well as more reliable sensor platforms, which drive up their costs. The accident mitigation capabilities of autonomously acting systems can also be achieved by an alternative strategy avoiding the high risk system reactions. The key is an early and reliable warning giving the driver time to react to the situation, combined with functions supporting the driver in his reactions, e.g. emergency braking. Early system reactions with low false activation rates can only be achieved by an advanced understanding of the traffic situation and an interpretation of the driver's actions in this context. To achieve this, the traditional approach of assessing the criticality of one potential collision object is extended towards observing and assessing multiobject scenarios. An analysis of accident statistics shows that in a high percentage of accidents the multiobject constellation provides additional information enabling early criticality assessments of the traffic situation. Using this information, the driver can be supported in an optimal way by an early, lowrisk

system reaction. This approach is the key for the vision “safety for everybody”, i.e. providing cost-effective collision mitigation functions with high collision mitigation capabilities to the mass market.

Paper Number 09-0187-O

Testing And Verification Of Active Safety Systems With Coordinated Automated Driving

Dr. Hans-Peter Schöner
Daimler AG, Germany
Dr. Stephen Neads
Anthony Best Dynamics Ltd., United Kingdom
Nikolai Schretter
Technical University Graz, Austria

Abstract:
Although more and more virtual development methods are used for testing and verification of active safety systems, there is still a need for extensive testing of the overall system in a *real* environment. The quantitative validation requires a wide range of different parameters to be controlled – most systems require adjustments of the speed of a „vehicle under test“ and a „target vehicle“ as well as their relative positioning in distance and angle. Using human drivers these parameters are only adjustable by performing a multitude of tests with statistically distributed results. Automatically driven manoeuvres offer the chance for a directed adjustment of all relevant parameters, requiring fewer tests, thereby creating a much more efficient testing operation. The technological challenge and control task is that two vehicles pass each other precisely at a predefined time and speed. Being able to control this, even tests which could not be performed up to now due to safety risks for the drivers, will be possible. The presentation reports on a common project of Daimler with Anthony Best Dynamics (ABD) and TU Graz, which resulted in a system using coordinated automatically driven vehicles. The need for precisely driven manoeuvres, resulting specifications for the testing methodology of coordinated path-controlled vehicles, and the challenges of its realisation will be explained. The resulting testing environment, hardware solutions and the methods for planning of safe testing trajectories will be illustrated. Results of the achieved accuracy are presented. A view on the role of this type of testing among other testing methods for precrash systems completes the paper.

Paper No. 09-0561-O

A Forward Collision Warning (FCW) Performance Evaluation

Garrick J. Forkenbrock
National Highway Traffic Safety Administration, United States

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Bryan C. O'Harra
Transportation Research Center, Inc. United States

Abstract:
This paper describes tests performed by the National Highway Traffic Safety Administration (NHTSA) to evaluate the forward collision warning (FCW) systems installed on three late model passenger cars. NHTSA defines an FCW system as one intended to passively assist the driver in avoiding or mitigating a rear-end collision via presentation of audible, visual, and/or haptic alerts, or any combination thereof. The test maneuvers described were designed to emulate the top three most common rear-end pre-crash scenarios reported in the 2004 GES database. FCW system performance was quantified by specifying the average time-to-collision (TTC) between the subject vehicle (SV) and principle other vehicle (POV) at the time of the SV's FCW alert.

Paper Number 09-0398-O

Method To Assess The Effectiveness Of Active Pedestrian Protection Safety Systems

Stefan Schramm
Department of Automotive Technology, Technical University Munich
Franz Roth
Audi AG

Abstract:
The effectiveness analysis assesses the benefit of future safety systems in terms of collision mitigation or collision avoidance based on real life accident data. The safety systems are evaluated by case-by-case analyses based on in-depth accident data (e.g. GIDAS). For this purpose an innovative simulation environment was developed that recreates the technical specification of the proposed system consisting of function algorithm, sensor, and actuators. Therefore results of component tests and complete system tests are included into the simulation. The accidents from the database are varied in the simulation by applying stochastic methods, guaranteeing the validity of the results from a statistical viewpoint. In addition to technical parameters such as a reduction in collision speed, the evaluation also includes a reduction in collision probability. Furthermore, when evaluating the functions a distinction is made between controlled and regulated actions. For each type a special simulation technique is used, which on the one hand is a purely offline analysis of previously simulated data and on the other hand an online or in-the-loop simulation. In order to be able to consider driver reactions on defined warning strategies realistically, it is essential to integrate a driver behaviour model into the simulation. To determine the driver behaviour, studies with probands are conducted using a new simulator technology. The test scenarios for these proband studies are based on accidents of the internal Audi accident research unit (AARU) database. In order to convert the technical evaluation parameters of the accident, e.g. collision speed, to injury severity, injury-risk-functions are required. To sum up, a new method of assessing the effectiveness of integrated

Technical Session
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safety systems will be presented, which incorporates new simulation techniques, driving experiments and real life accident data to assess a well-founded evaluation of integrated safety systems.

Paper Number 09-0132-O

Pedestrian Injury Mitigation By Autonomous Braking

Erik Rosén, Jan-Erik Källhammer, Dick Eriksson, Matthias Nentwich, Rikard Fredriksson Kip Smith
Autoliv Research, Sweden

Abstract:
The objective of this study was to calculate the effectiveness of a pedestrian injury mitigation system that autonomously brakes the car prior to impact at reducing fatal and severe injuries. The database from the German In-Depth Accident Study (GIDAS) was queried for pedestrians hit by the front of cars from 1999 to 2007. Information on vehicle and pedestrian velocities and trajectories were used to estimate the field of view needed for a vehicle-based sensor to detect the pedestrians one second prior to the actual crash. The pre-impact braking system was assumed to provide a braking deceleration up to the limit of the road surface conditions, but never to exceed 0.6g. New impact speeds were calculated for pedestrians that would have been detected by the sensor. These calculations assumed that all pedestrians that were within the given field of view and not hidden by surrounding objects would be detected. The changes in fatality and severe injury risks were quantified using risk curves derived by logistic regression of the accident data. Summing the risks for all pedestrians, new casualty numbers were obtained. The study documents that the effectiveness of reducing fatally (severely) injured pedestrians reached 40% (27%) at a field of view of 40°. Increasing the field of view further led to only marginal improvements in effectiveness.

Paper Number 09-0328-O

Autonomous Braking Systems And Their Potential Effect On Whiplash Injury Reduction

Matthew Avery, Alix Weekes
Thatcham, United Kingdom

Abstract:
The paper estimates the benefits of low speed autonomous vehicle braking technologies (e.g. City Safety from Volvo) on reducing whiplash injuries, and whether driver adaptation is likely. Potential UK whiplash injury reduction and cost savings associated with autonomous braking systems are calculated. Assuming standard fleet wide fitment, predictions show autonomous braking systems (City Safety) could annually prevent 263,250 crashes, mitigate 87,750, and prevent 151,848 injuries, equalling nearly €2 billion savings in repair costs and whiplash compensation. In driver adaptation testing participants drove toward an inflatable target car at

15km/h without braking. Responses were collected from 99 driver tests, where the vehicle autonomously brakes preventing impact. 11% of drivers braked instinctively when approaching targets, and 95% of drivers stated they would not rely on City Safety for normal driving, and understood that it was for emergency braking only. Feedback was also gathered from 11 drivers experiencing the system on thoUnited Statesnds of kilometres of normal UK roads. None reported either positive interventions or false interventions. City Safety, an example of low speed autonomous braking systems, shows huge potential for reducing crashes and whiplash injuries valued at nearly €2 billion in insurance claim savings. Other current autonomous braking systems operating at higher speeds require driver activation, and can only mitigate impact speeds. City Safety operates autonomously at low speeds and can prevent collisions occurring completely, so no risk compensation issues are expected.

Paper Number 09-0137-O

eVALUE – A Test Programme for Active Safety Systems

Micha Lesemann, Mohamed Benmimoun, Jörn Lützow, Adrian Zlocki, Prof. Stefan Gies
Institut für Kraftfahrzeuge (ika) – RWTH Aachen University, Germany

Abstract:
Active safety systems are massively implemented into new vehicle generations and offer a high potential in decreasing road accidents. While testing and rating of the passive safety of vehicles are based on established and accepted methods and programmes, no such are available for active safety of cars or trucks today. Thus it is difficult to assess the performance of those systems for industry, legislation and further stakeholders. In particular, the customer cannot judge about the active safety of different vehicles based on easy-to-understand ratings as they are offered by different NCAP programmes. This leads to a relatively low awareness of active safety systems and hinders a high market penetration.
The main focus of the European research project "Testing and Evaluation Methods for ICT-based Safety Systems (eVALUE)" is to define objective methods for the assessment of active safety systems. The methods are based on relevant traffic scenarios that, according to investigated statistics and databases, represent the majority of accidents, where active safety systems can come into effect. The considered systems are chosen based on market availability and penetration, e.g. ACC, Lane Keeping Assistant or ESC. Both the systems as well as the scenarios are clustered into four different domains, each being addressed with distinctive test procedures.
In the end, this new and highly needed test programme will allow the assessment of the overall safety performance of a vehicle with respect to active safety systems. However, the eVALUE consortium will only define the test methods while the thresholds for the specific values are not specified. This remains the competence of every institution adopting the test methods and actually applying them in order to assess different vehicles. The later results of the programme will increase the public awareness for active safety systems and foster the development within the industry.

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Paper Number 09-0447-O

New Test And Evaluation Methods For Future Car2x Communication Based Driver Assistance

Markus Glaab, Alois Mauthofer
carhs.communication GmbH, Germany
Udi Naamani
Connected Vehicle Proving Center, United States

Abstract:
Wireless communication technologies between cars and infrastructure (Car2X communication) will play a major role for future driver assistance. Many new applications and services in the fields of vehicle safety, comfort and infotainment will be possible. New test and evaluation procedures are required to cover future cooperative traffic scenarios with many cars and infrastructure equipment involved. An enrichment of real test situations with simulated environment scenarios ("Extended Reality") is proposed as an approach to develop and test such systems. An integrated development and test environment provides a flexible and configurable combination of both, real and simulated units including OnBoardUnits, RoadSideUnits, MonitoringDevices and on-board displays with modules e. g. for wireless communication (WAVE, DSRC, WLAN, UMTS), positioning (GPS), vehicle and infrastructure interfaces (CAN-Bus), which can be combined in any manner. Based on the integrated architecture a real Car2X testing scenario consisting of a car communicating with RoadSideUnit(s) providing traffic sign and traffic light information was first developed and tested in full simulation mode in the lab. Then the same scenario was validated in a real test car on the real test track of the Connected Vehicle Proving Center in UNITED STATES still with a simulated infrastructure environment. Based on that received information warning messages appeared on the on-board display. Active driver assistance functions can be triggered as well. The novel approach allows evaluation of the technology benefits and effectiveness with significantly reduced efforts as compared to traditional operational testing methods. This paper will cover the technology employed; the assistance and safety scenarios evaluated and give an outlook on the future use of the technology in combination with field operational tests.

Oral Presentations

Technical Session
Effect of Fuel Economy Strategies on Vehicle Safety

Oral Presentations | Wednesday, June 17th, 2009 | TRACK B | Room C5

Time: 09:00-12:30
Chairperson: Jac Wismans, Netherlands
Co-Chairperson: Kyong Han Yoon, Korea

Paper No. 09-0316-O

Characterizing And Enhancing The Safety Of Future Plastic And Composite Intensive Vehicles (PCIVS)

Aviva Brecher, John Brewer
Volpe National Transportation Systems Center, United States
Stephen Summers, Sanjay Patel
National Highway Traffic Safety Administration, United States

Abstract:
There is concern that a trend toward smaller, lighter, fuel-efficient vehicles could adversely affect overall fleet safety. Since 2006, the U.S. Congress has directed the National Highway Traffic Safety Administration to "*examine the possible safety benefits of lightweight plastic and composite intensive vehicles (PCIVs)"* with Federal and industry stakeholders. This paper identifies near-term research priorities and partnership opportunities to facilitate the deployment of safe and energy efficient PCIVs by 2020.
A critical literature review and focused survey of subject matter experts identified knowledge gaps on automotive composites crashworthiness and consensus safety research priorities. Initial results were published in a 2007 PCIV Safety Roadmap report with milestones to 2020. The roadmap was developed to address development of plastics and composites crashworthiness test standards, improved computational simulation tools, and automotive design strategies.
Additional inputs on key safety issues for automotive composites were obtained from an August 2008 experts' workshop, which examined in depth critical near-term research priorities and strategies to meet crash occupant protection challenges for future PCIVs. There is broad consensus that future PCIV structural composites with high energy absorption may enhance crash safety by preserving occupant compartment strength and protecting crush space. Near-term cooperative research is needed to:

- improve understanding of composite failure modes in vehicle crashes,
- develop a database of relevant parameters for composite materials, and
- enhance predictive models to avoid costly overdesign.

PCIV safety research is synergistic with ongoing NHTSA research (hydrogen and alternative

fuel vehicle safety, integrated safety, crash occupant protection), the US Government (DOE/USCAR consortia), and the global automotive industry and research community. This paper concentrates on safety-related research issues, assuming that other potential barriers to PCIV deployment (e.g., economic viability, manufacturability, sustainability) will be resolved. An updated safety roadmap and supporting cooperative research efforts are planned to facilitate the development and deployment of PCIVs with equal or superior crash safety by 2020.

Paper Number 09-0507-O

Status Of NHTSA's Hydrogen And Fuel Cell Vehicle Safety Research Program

Barbara Hennessey, Nha Nguyen
National Highway Traffic Safety Administration, United States

Abstract:
Safety information is vital to support the FreedomCAR and Fuel Partnership, a cooperative automotive research effort between the U.S. Department of Energy, the U.S. Council for Automotive Research (USCAR), and fuel suppliers. This partnership began in 2003 as part of the President's goal to reduce U.S. dependence on foreign oil, improve vehicle efficiency, reduce vehicle emissions, and make fuel cell vehicles a practical and cost-effective choice for large numbers of Americans by 2020. NHTSA's safety initiative complements these efforts by conducting research to support determination of fuel system integrity performance criteria that address the unique hazards posed by the onboard storage of hydrogen and the operation of high voltage fuel cells used to provide electrical current for hydrogen fuel cell vehicle (HFCV) powertrains.
This paper provides a description and timeline of the research tasks initiated in fiscal year 2009 to support the development or acceptance of proposed safety performance criteria for HFCVs. This is the third such status report published in these conference proceedings [1,2].

Oral Presentations

Technical Session
Biomechanics continued: Injury Criteria and Virtual Test Procedures/Tools Development

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Oral Presentations | Wednesday, June 17th, 2009 | TRACK B | Room C5

Time: 9:00-12:30
Chairperson: Philippe Vezin, France
Co-Chairperson: Stephen Ridella, United States

Paper Number 09-0253-O

Characteristics Of Fatalities In The Ciren Database

Peter G. Martin Stephen Ridella
National Highway Traffic Safety Administration, United States
Patricia C. Dischinger Gabriel E. Ryb Cynthia Burch Shiu Ho
National Study Center for Trauma & EMS University of Maryland School of Medicine Baltimore, Md., United States

Abstract:
This paper examines whether CIREN fatal cases are representative of crash fatalities in terms of injury patterns and the time to death. To examine the association, CIREN fatalities are compared with those of all motor vehicle crashes. Comparison data sets are derived from FARS data and from records obtained from the Maryland Office of the Chief Medical Examiner. Differences in injury patterns between those who died early-on vs. those who died later are documented. The findings suggest that the CIREN dataset is representative of real-world fatalities in terms of the fraction of deaths occurring within thirty minutes of the crash; and that, as expected, occupants who die early-on in CIREN are observed to have more severe injuries than those who die later. Moreover, injuries among early-on deaths appear to have a slightly different distribution than among those who die later. Also, CIREN has a higher fraction of cases where occupants died after twenty-four hours than in the U.S. population. The results of this study will help to refine methods used to estimate mortality associated with particular injuries by assessing the completeness of injury records for fatal cases.

Paper Number 09-0365-O

Reconstruction Of A Real World Crash Involving A Child Using Hybrid III 10-Year Old And 5th Percentile Adult Female ATDS

Technical Session
Biomechanics continued: Injury Criteria and Virtual Test Procedures/Tools Development

Joseph Ash, Jeff Crandall, Dan Parent
University of Virginia, Center for Applied Biomechanics, United States
Chris Sherwood
Insurance Institute for Highway Safety, United States
Kristy B. Arbogast
Children's Hospital of Philadelphia, United States

Abstract:
Validation data for child anthropomorphic test devices (ATDs) are scarce, making it difficult to assess their biofidelity. The goal of this study was to use previously collected real-world data involving a frontal crash with a child occupant to assess the biofidelity of current child dummies. The 9-year old child's anthropometry placed him between the size of the Hybrid III 10-year old and 5th-percentile Adult Female (AF5) dummies. Though injuries on the child indicated that he was properly belted, there were contact points on the vehicle interior and the exact position of the child before the accident could not be definitively determined from the crash investigation. Sled tests with identical seat belts and bench seat were conducted with the HIII-10 year old (n=9) and AF5 (n=6) in various seating configurations to explore the possible posture of the child before the accident. The tests were designed to reproduce the predicted Delta-V of 51 km/h with a smaller subset of the tests performed at 59 km/h to assess the implications of a higher speed on occupant contacts. Video analysis was performed to determine trajectories of the dummy head, chest, pelvis, and extremities. Despite the variation in speed, neither dummy was able to achieve the maximum head excursion necessary to make contact with the dash board. The results suggest that the dummies may underestimate the magnitude of excursion experienced by the child involved in the actual crash. To further investigate this finding, a sensitivity study was carried out using MADYMO Hybrid III 5th percentile female model. In addition to making use of existing data to further the investigation of child dummies, this study examines the biofidelity of two dummies used in child response approximation.

Paper Number 09-0268-O

Comparison Of Dynamic Responses Of The Thor-NT And Hybrid III In Offset Frontal Crash Test

Masayuki Yaguchi, Koshiro Ono
Japan Automobile Research Institute, Japan
Mitsutoshi Masuda, Takatomo Watamori, Takeshi Seshita, Tatsuya Hibino
Japan Automobile Manufacturers Association Japan

Abstract:
A64 km/h offset frontal crash test was conducted with the THOR-NT and Hybrid III to investigate the responses of both dummies under a crash situation that includes both deformation and rotational behavior of a vehicle. Though the dummies were installed in the driver seat according to the ECE R94 positioning procedure, their postures were slightly different. The head and heels of the THOR-NT were positioned rearward. Similarly, the shoulders and knees were positioned forward compared to the Hybrid-III. Therefore, it is expected that these differences will affect the

responses of both dummies. During the tests, both dummies showed similar kinematics, except for the rotation about Z-axis of the head, and the contact situation to the instrument panel of the arms. For the injury measures, the chest acceleration of the THOR-NT showed sharp inclination at 100 ms to 120 ms, presumed to be caused by the contact between the arms and instrument panel. The initial time history curve of the lap belt force was approximately the same between both dummies; however, the maximum force of the THOR-NT was less than half of the Hybrid III. For this difference, it was strongly presumed that more kinetic energy was absorbed by the knee bolster for the THOR-NT since its longer femur shortened the initial clearance between the knee and knee bolster. In addition, it was also presumed that the difference of the flesh characteristics around the iliac wing between both dummies affected the results. The injury measures of both dummies were compared to the injury criteria specified in FMVSS 208 and ECE R94. As for the results, almost equivalent values between the two dummies were observed. Moreover, as reference, the additional injury measures in the THOR-NT are shown in this paper.

Paper Number 09-0372-O

Improvement Of Dummy Positioning And Vehicle Parts During A Crash Through The Integration And Filtering Of Inertial Sensors

Andrés Aparicio, José Manuel Barrios, Eva Palacios, Arturo Dávila, Jaime López
IDIADA Automotive Technology SA (1) Spain

Abstract:
The objective of this paper is to discuss the potential capabilities of inertial sensors for point tracking and the presentation of a new tool which is able to place vehicle and dummy parts in 3D during a crash. This tool can help in the understanding of crash dynamics and optimize restraint system integration as well as CAE correlation.
This paper analyses the uses given to inertial sensors in crash applications, describes the errors obtained and proposes methods to correct them. The use of accelerometer-only based and accelerometer and gyroscope-based platforms is discussed. Recommendations for placement, filtering and calculation methods are given. A tool able to track in 3D the trajectory of a point is presented and the limitations found are commented.
The sled tests carried out to obtain relevant information are presented. Possible applications in current tests and probable new tests exploiting the capabilities of the new tool are suggested.

Paper Number 09-0407-O

Objective Rating Of Signals Using Test And Simulation Responses

Christian Gehre
PDB – Partnership for Dummy Technology and Biomechanics, Germany
Heinrich Gades
VOLKSWAGEN AG, Germany
Philipp Wernicke
BMW Group, Germany

Technical Session
Biomechanics continued: Injury Criteria and Virtual Test Procedures/Tools Development

Abstract:
Today the numerical simulation is an inherent process of the development of the passive safety of vehicles. Robust and predictable computational models are the base of successful application of numerical simulations. The evaluation of the level of correlation of those models to the real world needs objective and reliable rating methods. In the past this rating was either done by engineering judgment or by analysing single peaks or zero-crossings of response curves in comparision with test data. Nowadays, it is common agreement that for an objective rating the complete curve data have to be taken into account.
In this paper, a new method is presented that provides an objective evaluation of whole response curves coming from test and simulation. The method combines two independent sub-methods, a corridor rating and a cross-correlation rating. The corridor rating evaluates the fitting of a response curve into user-defined or automatically calculated corridors. The cross-correlation method evaluates phase shift, shape and area below curves. It was found that the use of both of these two sub-methods is essential because the disadvantages of each sub-method are compensated by the other method. Both methods were implemented into a tool called CORA – correlation and analysis. The philosophy of this tool is to separate engineer's knowledge from the algorithms. External parameters to adjust the algorithms are representing this knowledge. So it is possible to tune the evaluation to the specific needs of the application. The rating method was successfully used in a project on the improvement of Hybrid III 50th dummy models. It was possible to distinguish qualitatively and quantitatively between different releases of the model. In summary, the development of this rating method is a step forward to get an objective quality criterion of computational models.
In a next step the robustness of the rating will be analysed by varying the external parameters. Furthermore, the tool will also be used to analyse and evaluate results of physical tests.

Paper Number 09-0249-O

Creating Representative Curves From Multiple Time Histories Of Vehicle, ATD And Biomechanics Tests

Guy S. Nusholtz, Timothy P. Hsu, Yibing Shi, Sadegh Babaii, Kochekseraii Manuel Alejandro Gracián Luna
Chrysler LLC, United States

Abstract:
When test responses from specimens such as Post-Mortem Human Surrogates (PMHS), anthropomorphic test devices (ATD) or vehicle crash events are "perfectly repeatable," the response in terms of transducer time histories is similar and the output from any one of the tests can be used to represent any other test. However, if there is test-to-test variability, the underlying fundamental response as obtained by the transducer time history is not determined by a single test and methods are needed that can use multiple tests to reduce the inherent error. This paper will explore, using different transducer time histories from PMHS, ATD and vehicle tests, the effect of signal alignment and signal "shape" on the

results from signal addition. New procedures for transducer time history alignment and signal addition will be introduced and discussed, and different methods of obtaining the underlying response will be evaluated.

Paper Number 09-0016-O

Study Of Vehicle Dynamics And Occupant Response In Side Impact Crash Tests

Brock Watson, Duane Cronin, Brett Campbell
University of Waterloo, Canada

Abstract:
Side impact crash is a leading cause of fatalities on the roadways of the industrialized world. In the mid 1990's NHTSA implemented a new car assessment program testing the lateral crashworthiness of vehicles entering the market with a moving deformable barrier. Previous work has been done in an attempt to distill these tests into finite element simulations using specific vehicle test results; however there has not been a comprehensive study attempting to develop a model that includes a large number of tests to evaluate trends in vehicle kinematics and how they affect the occupants coupled with finite element simulations. To this end, a study of side NCAP tests was performed on all sedans based on the test results reported in the NHTSA Vehicle Crash Test Database since the introduction of the 2005 model year. This data was used to evaluate typical motion of the target vehicle during a regulatory crash test, and the corresponding occupant response. This sample consisted of new models entering the market and nameplates with major redesigns with a sample size of 72 vehicles. From these tests a series of velocity profiles were developed including time versus average velocity plots for vehicle center of gravity, door sill, driver's seat and driver door. These parameters have been shown to be important in occupant response and injury. There was significant variability in the response at several accelerometer locations. It was also found that rotation of the vehicle did not become significant until after 100 ms, after the maximum injury was predicted by the dummy. A parametric finite element analysis was performed using the both the USSID and ES-2re models to study the response of a restrained occupant during a typical crash test. These simulations showed that the velocity of the intruding door had a large effect on the thoracic injury predicted by the side impact dummy models.

Paper Number 09-0244-O

Development Of A Motorcycle Rider Model With Focus On Head And Neck Biofidelity, Recurring To Line Element Muscle Models And Feedback Control

Filipe Fraga, Lex van Rooij
TNO Automotive – Integrated Safety
Riender Happee
BioMechanical Engineering, Faculty of Mechanical Engineering, Delft University of Technology
Jac Wismans
SafeTeq, The Netherlands
Ioannis Symeonidis, Steffen Peldschus

Technical Session
Biomechanics continued: Injury Criteria and Virtual Test Procedures/Tools Development

Institute of Legal Medicine, Ludwig Maximilian University, Munich Germany

Abstract:
Despite continuing improvements in vehicle safety, motorcyclist casualties are estimated between 13% and 17% of road fatalities. Looking at the last two ESV conferences for a tentative measure of the research effort that is geared towards motorcycle safety, oral/written papers referring to two-wheelers averaged 6%/3% of each group. This tendency is also identifiable in the clearly lagging development of experimental techniques and computational models for the study of crash scenarios involving PTWs. This status quo prompts further developments of PTW-specific design tools to stem from existing occupant (and pedestrian) tools, rather than already available motorcycle-specific solutions.
This paper aims at filling some of that gap by proposing developments in computational models for motorcyclists alongside real-world trials. The paper concludes that a MADYMO human body model, equipped with PID-controlled neck muscles, reasonably maintains its biofidelic erect posture in sample scenarios, under the assumption that riders attempt to maintain their head upright. Preliminary results yield activation levels of up to 50 and 55% during severe (± 1,7G and 0,8G) longitudinal and lateral loading scenarios, respectively.
Preliminary volunteer trials (N=8) were conducted to provide initial validation in the event of braking. Although not yet complete, the analysis suggests that the resulting head kinematics for an average aware volunteer is compatible with the simulated response.
This development focuses R&D efforts on preventing injuries to the head-neck-complex, the body's most vulnerable region, by providing biofidelic postures and reactions to developers of personal protective equipment and advanced occupant/rider restraint systems. It also allows the evaluation of a motorcycle active safety system's impact on human response, which directly influences the consequences of the potential subsequent pre-crash or crash event. Finally, it represents a first step towards fully active human models, which will provide life-like pre-crash behaviour to e.g. OEMs, equipment and barrier manufacturers, and policy makers.

Oral Presentations

Technical Session
Rear Impact Injury Prevention & Protection

Oral Presentations | Wednesday, June 17th, 2009 | TRACK C | Room C7

Time: 09:00-12:30

Chairperson: Lynne Bilston, Australia
Co-Chairperson: Ola Boström, Sweden

Paper Number 09-0231-O

The Euro NCAP Whiplash Test

Michiel van Ratingen, James Ellway
Euro NCAP, Belgium
Matthew Avery
Thatcham, United Kingdom
Peter Gloyns
VSC, on behalf of ICRT, United Kingdom
Volker Sandner
ADAC, Germany
Ton Versmissen
TNO Science and Industry, The Netherlands
On behalf of the Euro NCAP Whiplash Group

Abstract:
Recently a new set of tests has been introduced in Euro NCAP that assesses the performance of front seats and head restraints in relation to the risk of whiplash-associated neck disorders in low severity rear-end collisions. In the absence of a clearly understood and generally accepted cause for these symptoms, the aim of this new procedure is to reflect real world seat performance, to highlight seats with known good and poor performance and to provide the maximum incentive to manufactures to move towards best practice in seat design.

Based on real world evidence and a review of the state-of-the-art in dummies, whiplash test experience and the real-world performance of commercially available seats on the market, a test procedure and criteria were developed that take into account both geometrical aspects and dynamic performance of the seat in three meaningful test severities.

Being one of the most comprehensive “whiplash” assessments of its kind, the paper provides the background and technical details to the procedure as well as a synthesis of the first results. The results highlight the potential for further improvement in the performance for the majority of car seats on the market today.

Technical Session
Rear Impact Injury Prevention & Protection

Paper Number 09-0533-O

Rear Impact Test Methodologies: Quasistatic And Dynamic

Brian R. Herbst
SAFE Laboratories, United States
Steven E. Meyer, Arin A. Oliver, Stephen M. Forrest
Safety Analysis & Forensic Engineering (S.A.F.E) United States

Abstact:
The performance of a vehicle's seat back in rear impact accidents can significantly affect occupant kinematics and resulting injury potential. The only current United States (U.S.) government regulation addressing seat back strength is outlined in Federal Motor Vehicle Safety Standard (FMVSS) 207, Seating Systems [1]. The test method outlined in this regulation is only partially predictive of seat performance in dynamic and/or real world impacts. Many seats continue to demonstrate gross deformations or catastrophic failures with potentially injurious occupant kinematics under the impact conditions of the FMVSS 301 Fuel System Integrity testing [2]. The Quasistatic Seat Test (QST) methodology, which utilizes an Anthropometric Test Dummy (ATD) and applies the load to the seat back through the ATD's lumbar spine, has been shown to be a predictor of seat deformation under dynamic loading [3]. Different seat designs tested utilizing the QST methodologies are presented.
Additionally, sled tests conducted at impact levels consistent with FMVSS 301 severities are presented and analyzed regarding occupant containment and the degree of encroachment of the deforming seat back or front seat occupant into the rear occupant's seating compartment. Crash test data, including ATD injury measures, from tests performed for the development of the recently upgraded FMVSS 301 rear impact standard were reviewed. Furthermore, an additional FMVSS 301 test is presented wherein a QST compliant seat was utilized to evaluate changes in ATD kinematics and injury measures

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Paper Number 09-0492-O

Detailed Analysis Of Biorid-II Response Variations In Hardware And Simulation

Klaus Bortenschlager
PDB – Partnership for Dummy Technology and Biomechanics, Germany
Markus Hartlieb, Andreas Hirth
Daimler AG, Germany
David Kramberger
Audi AG, Germany
Sebastian Stahlschmidt
DYNAmore GmbH, Germany

Abstract:
The BioRID-II rear impact dummy is used for assessing the level of protection of car seats against whiplash associated disorders (WAD) for many years. This level of protection is evaluated in consumer tests. For these tests comparatively low thresholds were introduced. Many questions which are related to injury criteria and their respective biomechanical tolerance levels remain unresolved. These low load ranges hold a claim against a high robustness of

measuring devices used with respect to repeatability and reproducibility. However, especially the low load range and the low signals from the sensors show a certain variation. Therefore, a reliable assessment of the level of protection of car seats is difficult.
The presented study is focused on the assessment of repeatability and reproducibility of the BioRID-II. A series of sled tests with eight individual BioRID-IIg dummies were conducted under well defined and controlled boundary conditions. The dummies were placed in four hard bucket seats to ensure stable test conditions and to avoid any variation generated by regular car seats. Variations caused by the seats and the seating procedures were minimized by testing every dummy in each seat. Particular attention was paid to very accurate test reruns to keep the test variations as small as possible.
Dummy certification tests prior and after the test series were conducted to determine possible changes of the dummy performance induced by the test program.
Finally, the study was completed by running simulations and parametric studies with the FAT BioRID-II FE-model. The objective of this computational investigation was the identification of potential caUnited Statestions for the variances particularly seen in the upper and lower neck responses.

Paper Number 09-0368-O

A Development Process For Creating Finite-Element Models Of Crash Test Dummies Based On Investigations Of The Hardware

Andreas Rieser, Christian Nußbaumer
Kompetenzzentrum - Das Virtuelle Fahrzeug
Forschungsgesellschaft mbH (ViF) Austria
Arno Eichberger, Hermann Steffan
Graz University of Technology, Austria

Abstract:
Crash test dummies act as a surrogate for humans in high loading conditions. Their anthropometry and properties have been retrieved in extensive research in the field of biomechanics. Accessibility to technical drawings and other specifications of crash test dummies is normally limited to their manufacturers. Furthermore, the hardware is affected by manufacturing tolerances, especially the complex shapes of dummies. Nevertheless reliable numerical simulation models are needed to support virtual engineering processes. In order to build up a Finite-Element-Method (FEM) simulation model, a process was defined to retrieve all relevant data by investigation of the hardware. The BIORID-II dummy was chosen to demonstrate this process. In a first step, it was necessary to capture the geometry of the BIORID-II. It is important to identify not only the exact geometry of every single part but also the assembly to know about the initial position. Different measuring methods such as optical 3D scanners, photographic analysis and manual measuring methods were used for this purpose. Based on these geometrical data FEM meshes were created. In a next step, functional characteristics of subassemblies were analyzed by separate testing. In case of the BioRID II - Dummy, the behavior of different springs, dampers and cables were determined, especially the characteristic of the materials. In the spine of the dummy several prestressed elements made of hyper-elastic materials exist, therefore not only the behavior of the material but also the initial condition were important. For validation purposes, three different tests have been used: the

prescribed calibration test, an additional sled test, both with the torso only, and a sled test with a car seat and the whole dummy. The numerical simulations showed good accordance in comparison to both hardware tests and component tests. The calibration test was passed.

Paper Number 09-0364-O

Japan New Car Assessment Program For Minor Neck Injury Protection In Rear-End Collisions

Takahiro Ikari, Kenichi Kaito
National Agency for Automotive Safety andVictims'Aid (NASVA), Japan
Taichi Nakajima, Kunio Yamazaki, Koshiro Ono
Japan Automobile Research Institute, Japan

Abstract:
The JNCAP intends to introduce a minor neck injury protection performance evaluation test method within the JNCAP program. Our research began with a 4-year project in 2005. In the first year, we conducted rear-end vehicle collision tests using a MDB to ascertain vehicle rear crash characteristics. In the second year, we conducted crash tests to allow changing the test conditions such as braking effect and excluding the influence of the MDB honeycomb. Basic data collected included floor G during a crash and measurement of the dummy injury level. In the third year, we conducted dynamic component sled tests to select an actual vehicle crash test or sled test. As a result, we found that the vehicle seat structure has a greater influence on the results than the vehicle structure. Additionally, in examining the sled acceleration pulse which represents the vehicle crash, we found that the crash characteristics of recent vehicles exhibited a triangular pulse rather than a trapezoidal pulse in the actual rear-end vehicle crash test. Delta-V is determined based on the cumulative figures for the rear-end crash accident speed rate. In the final year, all research results and conclusions were incorporated in our test protocol, and trial tests were conducted using the draft test procedure, which consists of the dynamic component sled test with a generic triangular pulse of delta-V=20 km/h. Effective evaluation indices will be finalized using recent biomechanical information. We will then publish all research results and present our final proposal.

Paper Number 09-0558-O

The Ability Of Rear-Mounted Convex Mirrors To Improve Rear Visibility

Dr. W. Riley Garrott Elizabeth N. Mazzae
National Highway Traffic Safety Administration, United States

Abstract:
The Cameron Gulbransen Kids Transportation Safety Act of 2007 requires the National Highway Traffic Safety Administration (NHTSA) to "initiate a rule-making to revise Federal Motor Vehicle Safety Standard 111 to expand the required field of view to enable the driver of a motor vehicle to detect areas behind the motor vehicle to reduce death and injury resulting from backing incidents, particularly incidents involving small children and disabled persons." It goes on to state that this may be accomplished "by the provision of ***additional mirrors*** (emphasis

added), sensors, cameras, or other technology to expand the driver's field of view." An advanced notice of proposed rulemaking was published on February 27, 2009. This paper examines whether rear-mounted convex mirrors could provide an image with sufficient quality that may be useful in aiding drivers in performing backing maneuvers.
There are three main configurations of rear-mounted convex mirrors: a single "look-down" mirror, a single corner mirror, and a pair of cross-view mirrors. NHTSA measured fields of view and image quality of one look-down mirror and three pairs of cross-view mirrors for passenger vehicle applications. Field of view and image quality were also estimated for one rear convex corner mirror based on previous research with that mirror relating to its use on medium straight trucks. Note that this study did not attempt to examine whether drivers will successfully use rear-mounted convex mirrors to successfully detect obstacles or pedestrians behind a vehicle. This question of potential overall effectiveness of rear-mounted convex mirrors, relative to other solutions to expand the driver's rear field of view, will be the subject of additional agency research.
The useful fields of view (FOV) of the five rear-mounted convex mirrors were determined. The potential backover risk reductions were estimated for the five mirrors studied, using only that portion of their FOV's with an image quality rating of better than "impossible." The estimated potential backover risk reductions ranged from 33.4 percent (for the Toyota 4Runner rear cross-view mirrors) to 2.2 percent (for the ScopeOut™ passenger car rear cross-view mirror).

Paper number 09-0302-O

The Study For Dynamic Evaluation Method For Assessing Whiplash-Associated Disorder In Rear Impact

Hiroyuki Asada, Katsumi Nawata, Masahide Sawada,
Japan Automobile Manufacturers Association, Inc. (JAMA), Japan
Koshiro Ono, Kunio Yamazaki, Taichi Nakajima
Japan Automobile Research Institute, Japan
(on behalf of the JAMA Rear-impact Neck Injury Evaluation Sub-Group)

Abstract:
FMVSS 202a and the head restraint gtr specify a dynamic sled test with Hybrid III dummy as an alternative to static tests. However, the poor biofidelity of Hybrid III dummy and the evaluation method based on the neck rearward rotational angle of the dummy during rear impact are urgent issues. To solve these issues, a dynamic evaluation of OC-T1 displacement, corrected for the seat back rearward inclination (hereinafter called "dynamic backset"), using BioRID II which has superior biofidelity, was studied to establish a test method with higher effectiveness, repeatability and reproducibility. From dynamic Backset evaluations by dynamic tests and simulations using IIWPG crash pulse on various types of seats and analysis of real world minor neck injuries involving such seats in Japan, the following new facts were found. (1) Dynamic backset can evaluate the effectiveness of various types of seats with whiplash mitigation features, such as reactive, passive, and WHIPS, more accurately than neck rearward rotation of Hybrid III. Since the seat effectiveness increases as dynamic backset decreases, it is appropriate for a dynamic evaluation parameter as an alternative of static backset tests. (2) By setting each seat back to its design torso angle, instead of 25 degrees for every seat, the variation in BioRID II installation is decreased, reactive and other non-static head restraints,

discussion had to be directed to the possible development of a dynamic evaluation method alternative to the static evaluation method. However, it was difficult to get all contracting parties consensus for selecting one common dummy for dynamic evaluation. Therefore, it was decided that each contracting party could select FMVSS202a dynamic evaluation method by using Hybrid-III dummy or could develop unique evaluation method by using BioRID II dummy. In Japan, although the number of road accident fatalities has been on the decrease, the number of rear-end accidents is on a marked rise (See Figure 1) and there is an urgent need to establish an appropriate method of evaluating the vehicle's occupant protection performance against the minor neck injury. Consequently the Japan Automobile Manufacturers Association ("JAMA") and the Japan Automobile Research Institute ("JARI") are conducting a joint study on the dynamic evaluation method using BioRID II to help the Japanese government introduce measures to protect vehicle occupants in rear-end collisions, because we have already studied that BioRID II has more better biofidelity than Hybrid III. resulting in higher repeatability and reproducibility. (3) According to the correlation analysis among real world accidents, minor neck injury phenomena, and various evaluation indicators, reduction of dynamic backset has an inhibitory effect on occurrence of minor neck injuries. (4) Confirming the relationship between other injury criteria

Paper Number 09-0371-O

City Safety – A System Addressing Rear-End Collisions At Low Speeds

Martin Distner, Mattias Bengtsson, Thomas Broberg, Lotta Jakobsson
Volvo Cars, Sweden

Abstract:

Rear-end collisions account for a substantial amount of crashes. The vast majority of rear-end collisions occur at speeds up to 30 km/h, mostly in city traffic. A common cause of these crashes is driver distraction. A rear-end collision might lead to soft-tissue neck injuries for the occupants in both vehicles involved, as well as material damages. The objective of this study is to present and discuss the potential benefit of a production system helping the driver to mitigate and in certain situations avoid rear-end collisions in low speed.

City Safety monitors the traffic in front with the help of a laser sensor that is built into the windscreen's upper section. It can detect the rear-end of a vehicle in front of the City Safety equipped car. If the driver is about to drive into the vehicle in front and does not react in time, the car brakes itself. The scope for the system is every day low speed scenarios, like cues or entering roundabouts, situations where a large portion of collisions appear due to distracted drivers. City Safety is active at speeds up to 30 km/h. If the relative speed difference between the vehicles is less than 15 km/h it can help the driver to avoid a collision completely. In relative speed differences above 15 km/h up to an absolute speed of 30 km/h the objective is to reduce speed as much as possible before a collision occurs.

Independent evaluation has shown that this technology offers the potential benefits of reducing collisions, leading to a substantial reduction in car damage costs and injuries to the occupants. Based on available statistics and dose-response model techniques, the reduction of impact severity is estimated to have the potential to reduce the risk of soft-tissue neck injuries in the rear-end impacted car by approximately 60%. Real-world retrospective studies of the production system will enable more precise quantification of the effect in the future.

Paper Number 09-0129-O

Technical Session
Rear Impact Injury Prevention & Protection

Pre-Safe® In Rear-End Collision Situations

Ralf Bogenrieder, Michael Fehring, Roland Bachmann
Daimler AG, Germany

Abstract:
In 2002 the first bridge between active and passive automotive safety was built. The MY03 Mercedes-Benz S-Class was the first car in the world that implemented preventive measures for occupant protection which took effect before the actual impact occurred. Meanwhile the name "Mercedes-Benz PRE-SAFE® System" became well known. Since then many other cars from various car manufacturers have adopted this principle of a "natural protection reflex". In order to detect dangerous situations or upcoming accidents, various sensor systems are being used in these cars today. In addition to sensors that keep an eye on the driving dynamics or on the driver reaction, the use of radar sensors or cameras has become common during the past few years. Almost all of those systems observe the area in front of the car and therefore address situations with an increased risk for a frontal impact. Very few systems presented up to now are capable to "look" backwards and thus detect an imminent rear impact. This paper presents the Mercedes-Benz approach to integrate this type of accident into the PRE-SAFE® System. The paper covers the issue of detecting collision objects on the basis of radar data. And it presents a cascade of precautionary actions that can improve occupant protection in rear-end accident situations. In particular, the purpose and benefit of a preventive increase of brake pressure is discussed, as well as taking into account further actuators such as a reversible seat belt pretensioner or an active headrest. In order to substantiate the benefit of such a system several evaluation charts on the reduction of the impact severity, the dummy loads and the estimated risk of whiplash injuries are included. Based on accident simulations there are also evaluations about the reduction of the "accident radius" and thus the risk of a secondary impact. Finally the question of an appropriate electronic architecture for such an integral safety system is touched upon.

Oral Presentations

Technical Session
Human Machine Interface - Issues, Driver-Vehicle Interaction Related Research, Impaired Driving and Human Factors Guidelines Development

Oral Presentations | Wednesday, June 17th, 2009 | TRACK A | Room C4

Time: 14:00-17:30
Chairperson: Claudio Lomonaco, Italy
Co-Chairperson: Lex van Rooij, Netherlands

Paper Number 09-0120-O

Logical Mediation Structures For Toyota's Driver Support Systems

Kazushi Kuroda, Iwao Izumikawa, Osamu Kouketsu
Toyota Motor Corporation, Japan

Abstract:
The driver support system (DSS) computer is an important part of systems such as adaptive cruise control (ACC), pre-collision system (PCS), and lane-keeping assist (LKA). The DSS computer receives information from peripheral sensors such as the forward radar, forward camera, and driver-monitoring camera, and transmits requests to controllers such as the engine, brakes, steering computer, and combination meter. DSS such as those listed above use the peripheral sensors in common and are also activated simultaneously, which makes it necessary to consider coordination among the systems. For example, if a part becomes inoperable, each system that uses the part reverts to a default condition and the condition of each system is shown on the combination meter. In such a case, the combination meter must not flash or show other such undesirable conditions. Therefore the behavior of these systems must be fully taken into consideration and guidelines for mediation constructed in terms of ergonomics. As a result, three aspects of design for mediation must be reviewed: diagnostic design, control design, and human-machine interface (HMI) design. These are all important for effective coordination among these systems.

Paper Number 09-0104-O

Emotional And Behavioral Response To Auditory Icons And Earcons In Driver-Vehicle Interfaces

Pontus Larsson, Anders Opperud, Krister Fredriksson
Humans Systems and Structures, Volvo Technology Corporation

Technical Session
Human Machine Interface - Issues, Driver-Vehicle Interaction Related Research, Impaired Driving and Human Factors Guidelines Development

Daniel Västfjäll
Applied Acoustics, Chalmers University of Technology, Sweden

Abstract:
Adequately designed, auditory displays in Driver-Vehicle Interfaces (DVIs) may give shorter reaction times, improved attention direction, and an increased quality impression. In this paper, we argue that emotional reactions may guide the design of such auditory displays since emotion is central in our everyday life and have strong consequences for behavior and information processing. A simulator study with 30 participants (20 of which were professional drivers) was conducted to investigate the connection between emotional and behavioral responses to auditory DVIs as well as to evaluate various sound design parameters in realistic driving situations. Auditory icons were contrasted to abstract earcon sounds in more or less imminent collision scenarios and 3D sounds were tested against monophonic sounds in different lane change scenarios. Self-report measures (Self-Assessment Manikins, SAM) and physiological measures (Galvanic Skin Response, GSR and facial Electromyogram, EMG) of emotional response as well as behavioral measures
(e.g. brake response time) were used. It was found that auditory icons were more efficient and gave up to 600ms faster brake response times than abstract sounds in imminent collision scenarios and that 3D sound gave a stronger emotional response in lane change scenarios. Moreover, the results show that emotion can predict behavior, e.g. sounds rated as being more activating and negative also gave quicker response times. Contrary to our expectations however, the findings from the SAM ratings were not reflected in the physiological measurements. An explanation to this may be that the scenario itself caused a dominant stress reaction which overrode the physiological response to the warning sounds. Our findings nonetheless strengthen the importance of auditory displays as a means to enhance vehicle safety, and that emotions may be an efficient way of predicting behavioral response to auditory DVIs. Measurements of emotion may therefore facilitate the process of designing auditory DVIs.

Paper Number 09-0240-O

Interacting Drivers At Intersections: What Can Make Them More Safe And More Efficient?

Maura Houtenbos
SWOV Institute For Road Safety Research, The Netherlands

Abstract:
Technological applications not only affect individual behaviour in traffic, but also influence interaction behaviour. However, not much research has been conducted in this area. This paper attempts to fill the gap by investigating the effects of manipulations of the time and space ("interaction space") drivers have to safely negotiate an intersection. Interaction space was manipulated by providing drivers at intersections with information about other approaching drivers, and also by varying the expectedness of the approach speed of the other driver. An experiment was conducted using an innovative and promising approach with two linked driving

simulators, where participants (N=26) were provided with in-vehicle information (flashing lights in their dashboard and beeps), indicating the direction and speed with which another driver approached on the intersecting road. Based on the right of way regulation, speed could be either expected or unexpected. The use of linked simulators allowed the participants to interact with a real driver (the experimenter), rather than with pre-programmed drivers and thus provided important information concerning the interaction process . Different behavioural indicators of the safety and efficiency of the interaction process were recorded. Also, concerning the information provided, the level of acceptance and experienced mental effort is reported. The results regarding the behavioural indicators suggest a proactive and reactive stage within an intersection approach, where the latter stage seems more prone to manipulations of interaction space. The acceptance results indicated that the lights were not appreciated whereas the beeps were regarded as quite useful. Mental effort was (subjectively) lower in the condition where extra information was provided. This experiment provides a valuable indication of the effect information would have on driving behaviour, although it should be noted that the precise way information was provided here is too simplistic for direct application in real traffic.

Paper Number 09-0531-O

Implications for HMI design: Understanding age induced limitations on invehicle task complexity

Joonwoo Son, Yongtae Lee, Manho Kim
DGIST (Daegu Gyeongbuk Institute of Science & Technology), Korea
Bryan Reimer
Massachusetts Institute of Technology AgeLab, United States

Abstract:
Recent technological advances have enabled a wide variety of information systems to be integrated into a vehicle in order to increase productivity, safety, and comfort. However, improperly deployed technology can degrade safety and annoy drivers. Especially, potential information overload problems may become acute among older drivers who are the fastest growing segment of the driving population. This paper aims to understand the age-related driving performance decline under a series of increasingly complex in-vehicle auditory tasks (nbacks). Data was drawn from a series of single task exercise and repetitions of the tasks under simulated driving conditions. In the simulation, 63 participants aged 20's and 60's drove through either a complex city or highway paradigm, appropriately counterbalanced. At a specified location in the canter of each of the two contexts, participants were asked to complete a series of auditory tasks of increasing complexity. Before beginning and after completing the simulation, drivers were asked to complete the auditory task in stationary non-driving conditions. Comparisons of younger and older drivers' secondary task performance will be discussed. In addition, differences in driving performance including average speed, speed variability, and lane keeping performance will be used to gauge older adult's capacity to regulate the demands of complex in-vehicle tasks in safe manner.

Technical Session
Human Machine Interface - Issues, Driver-Vehicle Interaction Related Research, Impaired Driving and Human Factors Guidelines Development

Paper Number 09-0247-O

Exploitable Characteristics Of Driver Braking

Nick Gkikas, John H. Richardson
Ergonomics and Safety Research Institute - Loughborough University, United Kingdom
Julian R. Hill
Vehicle Safety Research Centre - Loughborough University, United Kingdom

Abstract:

Previous work (Perron et al., 2001) on emergency brake application concluded that driver population diversity and "the overlap of braking parameter distributions between normal conditions and emergency situations" is such, that triggering criteria cannot both detect all emergency braking actions and never activate the assistance in situations where it is not necessary. The objective of this study was to investigate driver-braking characteristics, in order that future systems might achieve greater effectiveness.

48 drivers drove an instrumented vehicle on a public road section before arriving at a test track, where they were instructed to follow at their preferred distance another vehicle towing a trailer. They were told the aim was to measure their preferred car-following distance. They were naïve to the fact that 0.2 miles down the track the trailer would be released and rapidly decelerate to a stop. The main variables analysed included "throttle-off" rate, brake pedal pressure/force, and clutch pedal pressure/operation. The results indicate a series of relationships exploitable by an intelligent brake assist system. An intelligent brake assist system could take advantage of those characteristics and adapt its performance to individuals' braking style.

Limitations of the study include resource constraints (use of a single instrumented vehicle, time-limited access to the test track)and the contrived nature of the emergency braking scenario (need for surprise element, practically a one-off study, limitation of speed to 30mph/48kmph). The study provides evidence of a background for a customisable brake assist system that learns from the driver and adjusts its full-brake trigger accordingly.

Paper Number 09-0461-O

Test And Evaluation Of The Cooperative Intersection Collision Avoidance System For Violations (CICAS-V) Driver-Vehicle Interface

Miguel A. Perez, Vicki L. Neale
Virginia Tech Transportation Institute, United States
Raymond J. Kiefer
General Motors Corporation, United States

Abstract:

The Cooperative Intersection Collision Avoidance System for Violations (CICAS-V) project was conducted to develop and field-test a comprehensive system to assist drivers in reducing the number and severity of crashes at intersections due to violations at stop-sign and signal-

controlled intersections. One essential component of such a system is the Driver-Vehicle Interface (DVI) to warn a driver of an impending violation. A series of test-track studies was conducted to support the selection of a DVI for subsequent on-road tests of the CICAS-V. In these tests, 18 naive drivers per interface were placed in a surprise intersection violation scenario and provided with a precisely timed warning presented through a variety of DVIs. Driver braking profiles and vehicle stop locations were collected and analyzed, with particular emphasis on behaviors that resulted in avoiding entering the intersection DVIs included combinations of visual, auditory, and haptic (brake pulse) warnings. Results from the tests showed that drivers exposed to a brake pulse tended to stop more often and with lower decelerations than drivers that were not exposed to the brake pulse. The effectiveness of the brake pulse warning, however, was partly moderated by the type of auditory warning that accompanied the brake pulse warning. A baseline trial was conducted to determine the benefit of the DVI over a non-warning condition. Overall, results supported the recommendation of a DVI containing the simultaneous presentation of a flashing visual (red stoplight/stop sign icon), a 'Stop Light' speech warning, and a single brake pulse. The best-performing DVI resulted in an 88% improvement over the baseline condition. Project participants included offices of the United States Department of Transportation, Daimler, Ford, General Motors, Honda, Toyota, and the Virginia Tech Transportation Institute.

Paper Number 09-0293-O

An Analysis Of Speed-Related UK Accidents Using A Human Functional Failure Methodology

Claire Naing, Alan Kirk, Julian Hill
Vehicle Safety Research Centre, Loughborough University, United Kingdom
Pierre Van Elslande
Dept of Accident Mechanisms Analysis, INRETS, Salon-de-Provence
Sylvia Schick
Medical and Biomechanical Accident Unit, Institute for Legal Medicine, Ludwig-Maximilians-Universität, (LMU) Munich

Abstract:
Accidents involving either illegal or inappropriate speeding play a part in a large proportion of accidents involving cars. The types of typical failure generating scenarios found in car accidents where illegal speeding or inappropriate speeding is contributory are compared using the detailed human functional failure methodology developed in the European TRACE project (TRaffic Accident CaUnited Statestion in Europe), funded by the European Commission.
Using on-scene cases from the UK 'On The Spot' database (funded by the UK Department for Transport and Highways Agency), a sample of cases where speed is contributory have been analysed. An overview of speeding cases from the 4,000 in-depth cases available in the dataset is also presented.
The results highlight not only the differences between inappropriate and illegal speeding cases,

but also the differences in the functional failures experienced by both the 'at fault' and 'not at fault' road users in both types of speed-related accidents.
The results form a unique base of knowledge for future work on the human-related issues associated with speeding of both types, for all crash participants. Also considered is how new technologies can address speeding accidents.

Paper Number 09-0252-O

Comparison Between Adaptive And Basic Model Metrics In Lane Change Test To Assess In-Vehicle Secondary Task Demand

Hélène Tattegrain, Marie-Pierre Bruyas, Nicolas Karmann
LESCOT, INRETS France

Abstract:
The evaluation of driver's distraction due to driving assistance use requires the development of methods, which allow measuring the driving performance degradation. This paper aims to describe and discuss the metrics utilized in the Lane Change Test, which is developed to become a standard within the ISO framework.
The LCT consists in driving on a three lane road and performing lane changes according to signs displayed on each side of the road. The main metrics are based on deviation measures between a reference trajectory and the current driver trajectory. Two types of reference trajectories can be calculated following an adaptive or a basic model. The adaptive model calculates a reference trajectory different for each participant, while the basic one utilizes an identical one for all participants.
The differences between the two measures have been investigated through an experiment carried out with thirty participants, performing LCT in single and dual task conditions (using auditory and visual manual tasks).
Qualitative analyses of trajectories show the advantage of the adaptive model which better fits to the diversity of real driver's behaviour. Data analyses also show divergent results according to the models, especially in terms of correctness of lane changes. A greater number of correct lane changes is obtained with the adaptive model than with the basic one. These differences are mainly induced by trajectories classified as loss of control errors using the basic model due to usual positions in the lanes of the driver (tendency to drive on the right or left part of the lanes), that are considered as correct ones using the adaptive model.
The adaptive model allows a better description of lane change errors due to secondary task demand.
Such a method is now used by different laboratories involved in ISO group.

Paper No: 09-0266-O

Computer Vision Systems For 'Context-Aware' Active Vehicle Safety And Driver Assistance

Technical Session
Human Machine Interface - Issues, Driver-Vehicle Interaction Related Research, Impaired Driving and Human Factors Guidelines Development

Pinar Boyraz, Xuebo Yang, Amardeep Sathyanarayana, John H.L. Hansen
University of Texas at Dallas, Department of Electrical Engineering Richardson, TX, United States

Abstract:
The last decade has witnessed the introduction of several driver assistance and active safety systems in modern vehicles. Considering only systems that depend on computer vision, several independent applications have emerged such as lane tracking, road/traffic sign recognition, and pedestrian/vehicle detection. Although these methods can assist the driver for lane keeping, navigation, and collision avoidance with vehicles/pedestrians, conflict warnings of individual systems may expose the driver to greater risk due to information overload, especially in cluttered city driving conditions. As a solution to this problem, these individual systems can be combined to form an overall higher level of knowledge on traffic scenarios in real time. The integration of these computer vision modules for a 'context-aware' vehicle is desired to resolve conflicts between sub-systems as well as simplifying in-vehicle computer vision system design with a low cost approach. In this study, the video database is a subset of the UTDrive Corpus, which contains driver monitoring video, road scene video, driver audio capture and CAN-Bus modalities for vehicle dynamics. The corpus includes at present 77 drivers' realistic driving data under neutral and distracted conditions. In this study, a monocular color camera output is used to serve as a single sensor for lane tracking and road sign recognition. Finally, higher level traffic scene analysis will be demonstrated, reporting on the integrated system in terms of reliability and accuracy.

Paper Number 09-0340-O

Single-Trial Detection Of Cognitive Processes For Increasing Traffic Safety

Dipl.-Ing. Sebastian Welke
Center of Human-Machine Systems, GRK prometei, Technische Universität Berlin, Berlin, Germany
PD Dr.-Ing. Thomas Juergensohn
HFC Human-Factors-Consult GmbH, Berlin, Germany
Prof. Dr.-Ing. Matthias Roetting
Department of Psychology and Ergonomics, Chair of Human-Machine Systems, Technische Universität Berlin, Berlin, Germany

Abstract:
To increase driver's interaction with vehicles, research interest is growing to develop new approaches that allow for detecting the driver's intention. The extraction of features from electroencephalograph (EEG) data enables establishing a new communication channel by the

use of brain signals as additional interaction channel. So far, the applicability of EEG data in the context of driving is strongly limited by the robustness and ambiguity of the chosen features. The major goal of the presented approach is the robust discrimination of EEG patterns preceding intended actions of the driver for predicting upcoming manoeuvres. A pilot study on a test track containing elements of driver safety trainings was carried out. While driving, the manoeuvres the brain activity (64/32 EEG channels) and data from the car controller area network (CAN) was recorded. In this paper we present the bottom layer of a classification model for upcoming driver's movements by classifying left against right foot movement as well as left and right obstacle avoidance manoeuvres as sub-classes of the classes hand and feet movements. This way, we present two ways in which features extracted from EEG can be used: (1) by exploiting event-related potentials of independent components for identifying sources of consolidated neural activity, and (2) to establish the fundamentals of an approach for an EEG-based rapid-response system that can predict the upcoming action of the driver. The latter was done by an offline classification of variances in certain frequency bands of the EEG. Feature validation was implemented by spatial and functional filtering driven by independent components of the corresponding EEG datasets.

Paper Number 09-0406-O

Study Of Face Design, Lighting System Design For Enhanced Detection Rate Of Motorcycles

Kazuyuki Maruyama, Yojiro, Tsutsumi
Motorcycle R&D Center/Honda R&D Co., Ltd. Japan Yutaka, Murata
Future Transportation Systems Research Lab./Honda R&D Co., Ltd., Japan

Abstract:

The FACE (Facial Attention for Conspicuity Enhancement) design, a lighting system design that enhances motorcycle conspicuity with regard to the detection rate from the view of a driver at night, is described in this paper. Past research has shown that there is part of the human brain that reacts to the image of a face[1] and we thought of a method to enhance the detection rate of a motorcycle by incorporating the element of a face in the front design of the motorcycle. The effect of a simple FACE design, a reverse triangular arrangement of lamps, is evaluated and its effectiveness is shown. Moreover, we develop a simulation method that could be used to evaluate the enhanced detection rate of a FACE design motorcycle under conditions that are close to some real traffic environments. The method is evaluated by comparing it with the results of a full-scale test and demonstrates the method could be used to evaluate the detection rate of a motorcycle

Oral Presentations

Technical Session
Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Oral Presentations | Wednesday, June 17th, 2009 | TRACK B | Room C5

Time: 14:00-17:30
Chairperson: John Hinch, United States
Co-Chairperson: Dominique Cesari, France

Paper Number 09-0311-O

Evaluation Methods For The Effectiveness Of Active Safety Systems With Respect To Real World Accident Analysis

Dr. Markus Fach, Dirk Ockel
Daimler AG Mercedes Car Group, Germany

Abstract:
Starting around 1980 with the introduction of ABS, followed in 1995 with the presentation of ESP/ESC, and recently with the development of radar and camera based driver assistance systems, the automotive industry has introduced a great number of electronic systems with the specific goal of enhancing the active safety of vehicles.
The paper discusses evaluation methods for the effectiveness of modern Active Safety systems with respect to:

- Analyses of accident statistics
- In-depth studies on real world accidents
- Case by case evaluations of real world accidents and/or field studies
- Performance tests and measurements on test tracks

The paper gives an overview of the latest methods with their benefits and limitations as seen by an OEM.

Paper Number 09-0421-O

From 15% To 90% ESC Penetration In New Cars In 48 Months -The Swedish Experience

Maria Krafft
Anders Kullgren
Folksam Research

Technical Session
Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Anders Lie
Swedish Road Administration, Sweden
Claes Tingvall
Swedish Road Administration Sweden/Monash University Accident Research Centre, Australia

Abstract:
Electronic Stability Control (ESC) has been proven to be one of the most effective safety technologies, reducing serious crashes substantially. In Sweden the first attempt to stimulate the sales of ESC started in mid 2003. By using several market oriented methods the penetration rate on new cars reached over 90% 48 months later and is by late 2008 around 98%. In this paper, the methods to increase fitment of ESC, are presented, including actions from the government, administrations, insurance companies and the automotive sector. The results show that a structured implementation strategy can be very successful.

Paper Number 09-0374-O

Injury And Structural Trends During 12 Years Of NCAP Frontal Offset Crash Tests

Michael Paine
Australasian NCAP
Michael Griffiths
Road Safety Solutions
Jack Haley
NRMA Motoring & Services
Craig Newland
Australian Automobile Association, Australia

Abstract:
64km/h frontal offset crash tests are conducted by consumer crash test programs in Australia/New Zealand, Europe, the UNITED STATES, Korea and Japan. Data from ANCAP and Euro NCAP crash tests are analysed and trends for head, chest and leg protection and structural performance are discussed.
Vehicle designs have evolved to provide better occupant protection in frontal offset crashes. Consumer crash test programs have accelerated this process.

Paper Number 09-0387-O

Benefit Estimation Of The Euro NCAP Pedestrian Rating Concerning Real World Pedestrian Safety

Henrik Liers
Verkehrsunfallforschung an der TU Dresden GmbH (VUFO), Germany

Abstract:
In 2009, Euro NCAP intends to change its rating system. The new rating will put a greater emphasis on the pedestrian protection potential. Therefore, Euro NCAP endeavours to assess

the vehicle's overall safety performance and communicate it simply to consumers using a single star rating.
This study aims to estimate, how well the pedestrian rating system matches the expected real-world benefit. Furthermore, the benefit range achieved for different Euro NCAP pedestrian protection scores is determined. The vehicle impact zones and their related NCAP points are also evaluated for their actual effectiveness.
The analysis bases on the German In-depth Accident Study (GIDAS) database. A case-by-case analysis was carried out for 667 frontal pedestrian accidents where the vehicle speed was 40kph or less. More than 500 AIS2+ injuries are analysed regarding severity, affected body region, impact point on the vehicle, and the particular NCAP zone. An injury shift method was then used to determine the benefit derived from each testing zone.
One result of the study is a detailed impact distribution for AIS2+ injuries across the vehicle front. The rating colour code distributions for different vehicles with various higher point levels were compared to the original dataset and to the current standard in pedestrian protection. In order to estimate the overall benefit range, the analyses used optimistic and pessimistic approaches.
It is shown that current vehicles already exhibit significant real-world benefits. Furthermore, the additional benefit for vehicles achieving various point scores were estimated although the calculated benefits are mostly over-estimations due to missing test results for older vehicles and conservative assumptions.
This is the first detailed analysis of injury caUnited Statestion in NCAP zones and has been made possible by high accident numbers. Thus, the expected real-world benefits of any vehicles can be compared to their Euro NCAP t

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Paper Number 09-0464-O

Driver Alcohol Detection System For Safety (DADSS) – A Non-Regulatory Approach In The Development And Deployment Of Vehicle Safety Technology To Reduce Alcohol-Impaired Driving

SUnited Statesn A. Ferguson
Ferguson International LLC
Eric Traube
National Highway Traffic Safety Administration, United States
Abdullatif Zaouk
Qinetiq/Foster Miller
Robert Strassburger
Alliance of Automobile Manufacturers, United States

Abstract:
While government regulations play an important role in ensuring vehicle safety, voluntary approaches to the design and implementation of vehicle safety systems are increasing in importance as vehicle manufacturers deploy safety systems well in advance of, and even in the absence of, government regulations requiring them. This paper provides an overview of regulatory and non-regulatory approaches to vehicle technology development and deployment,

and will describe a new, innovative public\private partnership underway to develop an in-vehicle alcohol detection system. In response to concerns about limited progress in reducing alcohol-impaired driving in the United States during the last decade, attention is focusing on technological approaches to the problem. One strategy includes efforts to increase the application of current breath alcohol ignition interlocks on the vehicles of Driving While Intoxicated (DWI) offenders. However, in recognition that many alcohol-impaired drivers have not been convicted of DWI, an effort is underway to develop advanced in-vehicle technologies that could be fitted in vehicles of all drivers to measure driver blood alcohol concentration non-invasively. The Automotive Coalition for Traffic Safety (ACTS, a group funded by vehicle manufacturers) and the National Highway Traffic Safety Administration (NHTSA) have commenced a 5year cooperative agreement entitled Driver Alcohol Detection System for Safety (DADSS) to explore the feasibility of, and the public policy challenges associated with, widespread use of in-vehicle alcohol detection technology to prevent alcohol-impaired driving. This paper will outline the approach being taken, and the significant challenges to overcome.

Paper Number 09-0515-O

A Proposed Rollover And Comprehensive Rating System

Donald Friedman
Center for Injury Research, United States
Raphael Grzebieta
Injury Risk Management Research Centre University of New South Wales, Australia

Abstract:
The US, European and Australian New Car Assessment Program (NCAP) [1] and the Insurance Institute for Highway Safety (IIHS) produce ratings of new vehicle performance based on dynamic crash tests in frontal, side and rear crashes; and vehicle handling tests. No dynamic based crashworthiness ratings exist to date in relation to rollover crashes [2]. This study fills that gap and proposes a rating system for new vehicle performance in rollover crashes. Combined with existing rating systems, consumers will then have a complete and balanced picture of occupant protection performance. A database of more than 40 Jordan Rollover System (JRS) dynamic rollover tests [3], [4], [5] assessing injury potential by roof crush and crush speed has generically validated NHTSA and IIHS statistical data as a function of FMVSS 216 quasi-static, strength to weight ratio (SWR) [6]. There is however a wide disparity between the performance of individual vehicles at the same or similar SWR between the IIHS statistical and JRS dynamic test data. That disparity has been partially investigated in a companion paper in this conference (Vehicle Roof Geometry and its Effect on Rollover Roof Performance [7]). IIHS data indicated [8], [9] a 50% reduction in incapacitating and fatal injury risk with a fleet average SWR = 4. However, the use of a SWR-based rollover criterion does not provide sufficient crashworthiness fidelity essential for consumers, nor does such a criterion provide industry the opportunity to design cost-efficient rollover crashworthy vehicles based on occupant injury performance. Only a dynamic rollover testing protocol based on injury criteria would provide this information.

Paper Number 09-0217-O

A Safety Rating For Far-Side Crashes

Technical Session
Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Kennerly Digges, Cristina Echemendia
The George Washington University, United States
Brian Fildes
Monash University, Australia
Frank Pintar
Medical College of Wisconsin, United States

Abstract:
A research team from Australia, Europe and the United States has conducted the research needed to provide a technology base for far-side crash protection. To date the findings are as follows: (1) in the UNITED STATES and Australia there are large opportunities in far-side impact injury reduction, especially if safety features could mitigate injuries in both far-side planar impacts and rollovers, (2) a modified MADYMO human facet model was validated for use in evaluating far-side countermeasures, (3) either the THOR-NT or the WorldSID dummy would be satisfactory test devices for assessing far-side protection with minor modifications such as changing in the location of the chest instrumentation and (4) injury criteria and risk functions for use with WorldSID in far-side crashes have been documented. There is now a sufficient technology base so that far-side protection can be evaluated and rated by consumer information tests.

Paper Number 09-0261-O

Florida Standard For Crashworthiness And Safety Evaluation Of Paratransit Buses

Cezary Bojanowski
Jerry Wekezer
FAMU-FSU College of Engineering, Civil and Environmental Department, United States
Leslaw Kwasniewski
Warsaw University of Technology, Civil Engineering Department
Jerzy Kownacki
Motor Transport Institute, Vehicle Type-Approval and Testing Department, Poland

Abstract:
Research efforts on crashworthiness and safety assessment of paratransit buses were initiated and subsequently supported by the Florida Department of Transportation over the past ten years. They gradually evolved from computational mechanics feasibility studies using non-linear finite element (FE) methods to an industry standard implemented in the state of Florida in August 2007. Paratransit buses sold in Florida can now be evaluated for safety per the state standard based on either experimental testing or on rigorous computational mechanics analysis with validated FE models. Verification and validation (V&V) process is based on multi-scale laboratory testing including: material characterization, wall panel and connection tests, and testing of the entire bus. Validated FE models are subsequently used to provide a comprehensive safety assessment of the entire vehicle.

Technical Session
Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Two accident scenarios, identified as critical and dangerous by bus manufacturers and operators in the United States, are rollovers and side impacts. Rollover assessment for paratransit buses is based on a tilt table test. It was adopted for the Florida Standard from the UN-ECE Regulation 66 (R66) [1]. In addition, a side impact evaluation was introduced due to a significant segment of large SUVs and pickup trucks among all vehicles sold in the US. Penetration of the residual space is used as a failure criterion in both tests.
The computational track of the assessment program supported by the laboratory validation experiments is presented in the paper. A new method of safety margin assessment in the rollover test based on angular deformations of the bus cross section is introduced. The program has been well received and is now partially supported by the bus industry.

Paper Number 09-0299-O

Rear Occupant Protection JNCAP Test

Takahiro Ikari, Hiroshi Kawahara
NASVA (NationalAgency for Automotive Safety and Victims' Aid), Japan

Abstract
In June of 2008, it became mandatory in Japan for rear seat occupants to wear a seat belt under the new Road Traffic Act. Rear seat occupants involved in frontal collision traffic accidents in Japan are mainly women. Considering this situation, we will start to evaluate rear seat occupant safety performance in frontal collision tests using a Hybrid III AF05 dummy. The evaluation includes not only this dynamic collision test but also the United Statesbility of the rear seatbelt and seatbelt reminder for passengers including those in the rear seat, which is not mandated by the law. We will show in detail the methods for rear occupant protection in a frontal collision and the ease of use of rear seatbelt, which will be the first introduction worldwide by JNCAP.

Paper Number 09-0342-O

Development of the Virtual Testing Benchmarks (VTB)

Massimiliano Avalle
Politecnico di Torino, Italy
Kambiz Kayvantash
Cranfield University, United Kingdom
Ivan Gaviglio
Politecnico di Torino, Italy

Abstract:
The SubProject 7 "Virtual Testing" [1] of the 7th FP Project APROSYS (Advanced PROtection SYStems) was aimed at development of a complete and consistent methodology for the implementation of the virtual testing of vehicles for safety improvement. Recall that by Virtual Testing we imply any analytical certification procedure which uses experimental and numerical simulation methods [2]. To achieve this goal, specific models, methods, and tools were developed. One of the final achievements relates to the future use of virtual testing in

regulations, not only in the design of vehicles for safety [3]. The implementation of virtual testing in regulations would be a very complex process involving several steps [2], and concerning many different actors and stakeholders from car manufacturers to consumer organizations, and from regulatory bodies to experts group in automotive engineering. Among the many envisaged steps, which are being currently structured in a specific roadmap, there is the qualification problem. For both type of accreditation method, either the type approval scheme usual in the EU, or the US style self-certification scheme, a qualification process is required. To this aim the authors propose to establish a series of benchmarks, the Virtual Testing Benchmarks (VTB), to be used for qualification at two different levels: codes and methods validation, and operators' qualification. These benchmarks consist of typical crash cases to be tested in the virtual environment: there are several different cases covering different topics of modeling (different element types, material models, contacts…). The code validation can be achieved by giving a well defined problem to be solved, whereas the operators qualification can be achieved giving a less defined framework and leaving more freedom to the operators to generate their own models of the problem. At least 5 different cases are provided and described in the paper. Verification by means of experimental or theoretical solutions is given. Of course, this will not cover all possible modeling situations but is a first step towards this electronic certification.

Paper number 09-0275-O

CNG Cars Safety In Accidents (Case Study:Iran)

Alireza Zamanian, Iman Ghafghazi, Morteza Deljooye Sabeti
Traffic Expert, Metra Consulting Engineers Co., Iran

Abstract:
In the last decade, air pollution has become a major problem in metropolises.Therefore using alternatives for common fuels, especially gasoline was ordered. In a country like Iran with the second biggest natural gas resources in the world, CNG was the most important choice. This potential led to vast manufacture and United Statesge of CNG consuming automobiles. Being used in different climates and areas and because of the susceptibility of natural gas, these automobiles have always been vulnerable in accidents. Based on the statistics from reliable sources and scientific methodes, this research tries to present the order of importance of CNG fuel system parts in accidents. The results of this research will reveal the priority of making the system parts safe.

Paper Number 09-0215-O

The Basis For A Fluid Integrity NCAP Rating

Kennerly Digges, R. Rhoads Stephenson
The Motor Vehicle Fire Research Institute, United States

Abstract:
The frontal crash mode accounts for about half of the fires in FARS and NASS. Rollovers account for about 25% of the major fires in NASS and carry the highest risk of fatality in FARS fires. In NASS, the vast majority of fires that occur in frontal and rollover crashes originate

underhood. Many of these fires eventually engulf the occupant compartment. Incapacitation and entrapment of occupants are important survival factors when underhood fires occur. Tests of several vehicles under operational conditions indicated that the surface temperature of the exhaust manifold and catalytic converter can exceed the ignition temperature of many underhood fluids. NCAP tests should include leakage measurements of all fluids. If leakage is observed, ratings could be assigned based on the amount and flammability of any fluid leakage. Since rapid egress is needed when fire occurs, the force required to open doors should be a basis for the safety rating, as well. Finally, there is technology on-the-road for electrical disconnects of the fuel pump and battery. These features should be evaluated as part of the NCAP test.

Paper Number 09-0177-O

Future E/E-Architectures In The Safety Domain

Dr. Michael Bunse, Dr. Matthias Wellhöfer, Dr. Alfons Doerr
Robert Bosch GmbH, Chassis Systems Control, Business Unit Occupant Safety, Germany

Abstract:
The number of functionalities, sensors and control units in modern vehicles is increasing permanently. In spite of this, the OEMs aim to minimize these numbers to reduce complexity, effort and cost. Thus it is very important to find the most suitable E/E-architecture jointly with the OEM in order to cope with these challenges. Furthermore, the re-partitioning of content in the safety domain offers great opportunities for the OEM. First of all, it can reduce the overall costs, since the trend towards increasing active and passive safety systems offers synergies of components and functions: Driven by legislation, the installation rates of safety features like ESP® will rise significantly in some regions. Together with the fact that airbag systems in the triad markets have a take rate of almost 100% it is clear that there will be high potential in developing cost effective E/E-architectures. Consequently two main steps are necessary to cope with these challenges: The first step is finding a suitable integration concept for inertial sensors on the vehicle architecture level. The second step is cost optimization by using maximum synergies or high-integration concepts. Beyond cost reduction, the current functionality can be improved since the inertial sensors are directly connected on the same PCB-board with the airbag-algorithm controller in some integration concepts. This gives the possibility to feed the airbag-algorithm with inertial sensor data like for example the yaw rate. This yaw rate can be used in a yaw rate based airbag algorithm to further improve the performance. This paper gives an overview about the architectures and functions, discusses the pros and cons of the different concepts and gives an outlook for future systems.

Paper Number 09-0008-O

ISO 27956 -A New Standard Describing Requirements And Test Methods For Lashing Points And Partitioning Systems For Cargo Securing In Delivery Vans

Alexander Berg
DEKRA Automobil GmbH., Germany
Walter Sicks

Technical Session
Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Normenausschuss Kraftfahrzeuge im VDA, Germany
Jean-Pierre Cheynet
BNA Bureau de Normalisation de l'Automobile, France

Abstract :
According to the German Road Traffic Regulations, the cargo has to be secured in a vehicle so that it will not move, fall down, roll around, be shed or generate avoidable noise. This is required under normal conditions of operation including full braking, emergency braking, braking in a curve, fast lane changing and driving in a curve. The basis for a proper securing of cargo in delivery vans (N1vehicles) includes a robust partitioning system which fully or partially separates the occupant compartment from the loading space, as well as lashing points. The partitioning system retains the cargo during braking, for example. Lashing points serve to hold lashing devices to secure the cargo, e.g. lashing straps for tie-down lashing.
In Germany, partitioning systems and lashing points for commercially employed new vehicles covered by the scope of the Accident Prevention Regulation for Vehicles (BDG D29) have been mandatory since 1996. DIN 75410-3 "Securing of Cargo in Truck Station Wagons (Closed Body)", did apply here as the national technical regulation.
In order to anchor the tried-and-tested requirements regarding partition systems and lashing points in globally applicable regulations, the ISO/TC22/SC12 set up the workgroup WG9. On a voluntary basis non-governmental organisations and OEMs created the standard ISO 27956. As a result the national standard has not only been transferred into English but has also been further developed now. As the drafts ISO/CD 27956 and ISO/DIS 27956 were received favourably after their worldwide ballots, the final standard ISO 27956 has been approved now and will be published in the spring of 2009.
The paper will report on the necessity and the background as well as on the contents of this standard which may be used for self certification, for example. Prospects of further development of the Standard to cover latest additional equipment for load securing in delivery vans will be given as well.

Oral Presentations

Technical Session
Structural Integrity and Restraint Performance

Oral Presentations | Wednesday, June 17th, 2009 | TRACK C | Room C7

Time: 14:00-17:30
Chairperson: Suzanne Tylko, Canada
Co-Chairperson: Steve Summers, United States

Paper Number 09-0210-O

Why Passenger Survivability Cannot Be Completely Assured In Head-On Vehicle Impacts At Current Legal Speed Limits

Gustavo Zini
School of Engineering – University of Buenos Aires, Argentina

Abstract:
"This impact is intended to represent the most frequent type of road crash, resulting in serious or fatal injury. It simulates one car having a frontal impact with another car of similar mass". (EuroNCAP frontal impact procedures).

It can be argued that human bodies are poorly prepared to support direct hits from hard objects. On the other hand, there are proofs of resistance to very high decelerations, provided they are held for extremely short periods of time. Yet, in front-to-front vehicle impacts, a third phenomenon that can be compared to direct hits takes place: instantaneous changes of speed.

Most modern vehicles are nowadays tested thoroughly to evaluate their capability to protect their occupants in case of frontal impacts. But these tests are performed under the premise that the vehicle is having an impact with another car of similar mass that is traveling at the same speed. These conditions lead to an incomplete analysis of the complex phenomena that take place in a real front-to-front vehicle since it is statistically improbable that a vehicle will crash with another one that has both the same mass AND speed —and in this scenario, the vehicle with the lesser kinetic energy will unfailingly suffer an instantaneous change of speed—.

This paper will confirm the lastly mentioned issue using basic physics models (namely mass-spring models), and will discuss the way of combining structural integrity and occupant restraints to ensure the maximum possible protection. This will be done from a general and synergistic point of view, and will point out some aspects that should be developed thoroughly within the corresponding settings and using appropriate resources.

Paper Number 09-0331-O

Material Characterization Levels For Crashworthiness Applications

D. Muñoz, A. Mansilla
Fundación CIDAUT/ Department of Science of Materials and Mechanical Engineering. University of Valladolid, Spain

Technical Session
Structural Integrity and Restraint Performance

A. Regidor, J. Carlón
Fundación CIDAUT

Abstract:
During the last decades, numerical simulation of crash events has become one of the key topics in the reduction of costs for the phases of development of new automotive products. The former conception as a tool to provide qualitative support to designers has evolved up to the point of talking about “virtual testing” and about the feasibility of include it in standards and regulations. This evolution of the perspectives requires more and more predictive simulation models, leading to a continuous improvement in the mathematical reproduction of the physical reality. Within this background, the correct numerical reproduction of the material behaviour has a critic role. The techniques for material characterization have also evolved from the use of simplified curves obtained from scarcely instrumented tensile tests, including strain rate dependency in a higher or lower degree, up to the use of complex yield surfaces obtained from the exhaustive analysis of the local phenomena that occur during the necking process in tensile tests, as well as the inclusion of other load cases different to the uniaxial tension. The current paper reflects the results of some studies about the influence of different levels of material characterization on the correct reproduction of the material behaviour. The base case is the simulation of the characterization tests themselves, analyzing both local and global parameters for the validation of the models. Three different materials (one metallic and two plastics respectively) have been used in these studies, trying to deepen into their basic characteristics and requirements. Finally, a load case closer to a common energy absorption application has been chosen for the case of the plastics in order to illustrate and validate the hypothetical consequences of the use of the different material definitions.

Paper Number 09-0400-O

Car Crashes With Polytrauma In Southern Germany

Axel Malczyk
German Insurance Association – Accident Research, Germany
Edgar Mayr, Michael Ecker, Tobias Seebauer, Carla Weber,
Klinikum Augsburg, Abt. für Unfall-, Hand- und Wiederherstellungschirurgie, Germany
Lorenz Lampl, Matthias Helm, Martin Kulla,
Bundeswehrkrankenhaus Ulm, Abt. Anästhesiologie und Intensivmedizin, Germany
Linda Winkler
Universitätsklinikum Ulm, Germany
Florian Gebhard, Ulrich Liener
Universitätsklinikum Ulm, Klinik für Unfall-, Hand-, Plastische und Wiederherstellungschirurgie, Germany

Abstract:
Multiple, life-threatening injuries, often termed polytrauma, do not only demonstrate a high risk of mortality, but also for long-term or persistent disabilities for surviving victims. Road traffic accidents represent the most frequent cause for polytraumata in Germany. However, there are

only estimates for the annual incidence rate of these critical injuries and little information exists about the share of different road users among these patients and their respective injury patterns. This is partly due to the fact that – at least in Germany – these most severely injured cannot be identified from national traffic accident statistics. A multi-center study is being conducted in a large part of southern Germany that attempts to document all polytrauma cases from traffic accidents and the circumstances of the collisions in a defined geographical region over a 14-month period. Patients with an Injury Severity Score ISS > 15 and injuries in at least two body regions are included for evaluation. This paper describes injuries sustained by 34 car and minivan occupants during the first months of the study, the related collision configurations and the vehicle passive safety features that were used or activated, like seat belts and airbags. Most of the occupants were between 18 and 45 years old. More women than men had severe multiple injuries, especially in the range above 35 years of age. Drivers were by far the largest group among the patients and a substantial number of them were unbelted. Many of the involved vehicles were from the small or compact car segment and belonged to older model generations, but most of them featured driver and passenger airbags and sometimes also airbags for side protection. The most severe injuries (AIS 4 and 5) were those to the head and especially to the thorax. Severe spine injuries were few and limited to side impacts or ejection from the vehicle.

Paper Number 09-0483-O

NHTSA Research On Improved Restraints In Rollovers

Michael L. Sword
Transportation Research Center, INC., United States
Allison E. Louden
National Highway Traffic Safety Administration. United States

Abstract:
As part of a comprehensive plan to reduce the risk of death and serious injury in rollover crashes, the National Highway Traffic Safety Administration (NHTSA) has a program to characterize restraint system response in rollovers. A rollover restraint tester (RRT) is utilized to produce a 180 degree roll followed by a simulated roof-to-ground impact. Recognizing the unpredictability of the real world rollover phenomenon, this test provides a repeatable and consistent dynamic environment for suitable lab evaluation. Similar NHTSA research during the mid-1990s demonstrated an excursion reduction of up to 75% when an inflatable belt was compared to the standard three-point belt with a 50th percentile (50th) male dummy [Rains, 1998].

Technologies being considered include integrated seat systems, pyrotechnic and electric resetable pretensioners, four-point belt systems, and inflatable belts. High speed video data are collected and analyzed to examine occupant head excursion throughout the tests and are presented for discussion. The RRT has demonstrated to be repeatable; however, there are some concerns about the real world relevancy of the RRT dynamics in the absence of a lateral component. The RRT does not have a mechanical component for lateral motion that is typical in some real world rollover events.

This research attempts to determine if reducing occupant excursion during a rollover event is

possible by utilizing the RRT. Results presented at the 20th ESV conference demonstrated that excursion characteristics can be affected with the implementation of advanced restraints in the 50th percentile male dummy [Sword, 2007]. This paper presents expanded research with the 50th percentile male dummy and also includes the 5th percentile (5th) female and 95th percentile (95th) male dummies.

When compared to a baseline 3-point restraint, advanced restraints utilizing pretensioning and other technology reduced excursion of all the dummies in both the Y and Z directions, where the Y direction is lateral motion and the Z direction is vertical motion. The current production technologies, pyrotechnic and motorized retractors, were able to reduce Y and Z excursion in RRT tests, by up to 66% and 60%, respectively. The advanced restraints, inflatable belts and 4-pt belts, reduced excursion in the Y and Z directions up to 80% and 86%, respectively.

Paper Number 09-0501-O

Webbing Sensitivity As A Means For Limiting Occupant Excursion In Rollovers

Steven E. Meyer, Davis A. Hock, Arin A. Oliver, Stephen M. Forrest
Safety Analysis & Forensic Engineering (S.A.F.E.),United States
Brian R. Herbst
SAFE Laboratories, United States

Abstract:
Seatbelt performance in rollovers has come under increased scrutiny in recent years. This is due, in part, to growing popularity of sport utility vehicles which have a demonstrated inferior rollover resistance when compared to passenger cars [1]. In the United States (U.S.) the National Highway Traffic Safety Administration (NHTSA) has stated an intent to mandate an increase in the roof strength safety standard. Such an improvement in roof strength will undoubtedly bring an increased focus on the performance of seatbelts in rollovers. Many contemporary seatbelt retractors are equipped with both a vehicle crash sensor as well as a secondary, or backup, webbing sensor. The webbing sensor is intended as a backup locking device in the event of a failure of the primary inertially sensitive vehicle sensor. The crash modes presenting the most potential for the inertial sensor's failure include non-planar crashes, multiple impacts, and rollovers [2]. It follows, therefore, that to ensure reliable seatbelt retractor lockup in these modes, the redundant webbing sensor must be tuned with a lockup threshold consistent with expected occupant motions and webbing extraction rates seen during these events.
Rollover tests conducted by NHTSA wherein the belt systems were instrumented for both load and webbing payout were analyzed. This analysis provides insight for determining a baseline lockup threshold for the webbing sensor required to ensure activation in the rollover crash mode. Additionally, multiple retractors designed for both European and
U.S. markets have been tested on a bench-top sled. These tests were conducted to include out-of-plane accelerations similar to those observed in rollover crashes.
The retractor sled test results, along with the analysis of the NHTSA rollover tests, are then discussed and used to develop a suggested webbing sensor lockup threshold necessary to ensure the effectiveness of the redundant and backup webbing crash sensor in real-world events.

Technical Session
Structural Integrity and Restraint Performance

Paper No. 09-0502-O

Roof Strength And Injury Risk In Rollover Crashes Of Passenger Cars And SUVS

Matthew L. Brumbelow, Eric R. Teoh
Insurance Institute for Highway Safety, United States

Abstract:
A 2009 study by the Insurance Institute for Highway Safety found that midsize SUVs with stronger roofs, as measured in quasi-static tests, had lower risk of ejection and lower risk of injury for nonejected drivers. The objective of the present study was to determine whether a similar association exists for other vehicle groups.
Twelve small passenger cars were evaluated according to Federal Motor Vehicle Safety Standard 216 test conditions extended to 10 inches of plate displacement. Crash databases in 14 states provided more than 20,000 single-vehicle rollover crashes involving these vehicles. Logistic regression analyses were used to evaluate the effect of roof strength on the rate of driver injury while assessing and controlling for the effects of driver age, vehicle stability, state, and other factors where necessary.
Small cars with stronger roofs had lower overall rates of serious injury, lower rates of ejection, and lower rates of injury for nonejected drivers. Although the effect on ejection was somewhat smaller for cars than for SUVs, the overall pattern of injury results was consistent. For roof strength-to-weight ratio measured at 5 inches (SWR5), a one-unit increase (e.g., from 2.0 to 3.0) was associated with a 22% reduction in risk of incapacitating or fatal driver injury in single-vehicle rollovers. This compares with a 24% reduction estimated for a similar change in roof strength among midsize SUVs.
The association between vehicle roof strength and occupant injury risk in rollover crashes appears robust across different vehicle groups and across roof SWR5 values, varying from just more than 1.5 to just less than 4.0. If roofs were to increase in strength by one SWR5, a 20-25% percent reduction in risk of serious injury in rollovers would be expected. Still, even if all vehicle roofs were as strong as the strongest roof measured, many rollover injuries still would occur, indicating the need for additional research and countermeasures.

Paper Number 09-0555-O

A Study Of The Factors Affecting Fatalities Of Air Bag And Belt-Restrained Occupants In Frontal Crashes

Rodney W. Rudd, James Bean, Carla Cuentas, Charles J. Kahane, Mark Mynatt, Chris Wiacek
National Highway Traffic Safety Administration, United States

Abstract:
The combination of seat belt use and frontal air bags is highly effective in frontal impacts, reducing front-seat occupants' fatality risk by an average of 61 percent compared to an unbelted occupant in a vehicle without air bags. Nevertheless, a number of fatalities are still occurring. Whereas the safety community is generally aware of factors that make specific crashes fatal – e.g., extreme crash severity, compartment intrusion, occupant fragility – there is a need for

quantitative information on the relative frequency of these factors, and how often they occur in combination.
This study began with in-depth reviews of NASSCDS fatality cases. Case selection was limited to belted occupants in frontal impacts of late-model vehicles equipped with air bags. The reviews focused on coded and non-coded data, and resulted in the identification of factors contributing to the occupant's fatal injuries. The factors were compiled and analyzed by a team of NHTSA researchers including crash investigation specialists, crashworthiness and biomechanical engineers.
Factors were assigned based on their relevance, and emphasized those that have the potential of being addressed through vehicle design improvements. Many of the fatal crashes occurred under conditions that were considered more severe than what can be reasonably addressed with crashworthiness and restraint technologies. While the physical characteristics of some occupants were found to play a role in their demise, it was more common that the loading conditions from the crash were simply too injurious owing to a reduction in the occupant's survival space. Impact configurations with insufficient structural engagement or with oblique directions of force frequently result in degradation of structural integrity and occupant trajectories that reduce the effectiveness of restraint systems even in moderate-severity crashes. The findings of this study indicate that corner impacts and oblique frontal crashes should be a priority area for future research

Oral Presentations

Technical Session
Vulnerable Road Users: Pedestrian Safety

Oral Presentations | Thursday, June 18th, 2009 | TRACK A | Room C4

Time: 09:00-12:30

Chairperson: Hideki Yonezawa, Japan
Co-Chairperson: Wojciech Przybylski, Poland

Paper Number 09-0145-O

Development Of A Biofidelic Flexible Pedestrian Legform Impactor Type GTR Prototype Part 1: Development And Technical Evaluations

Atsuhiro Konosu and Takahiro Issiki
Japan Automobile Research Institute, Japan
Yukou Takahashi and Hideki Suzuki
Japan Automobile Manufacturers Association, Inc., Japan
Bernard Been and Mark Burleigh
First Technology Safety Systems, The Netherlands and the United Kingdom
Takahiro Hirasawa and Hitoshi Kanoshima
Ministry of Land, Infrastructure, Transport, and Tourism, Japan

Abstract:
Prototypes of the latest version of a biofidelic flexible pedestrian legform impactor (Flex-GTR-proto) were developed in November 2008. In this research several technical evaluations on the Flex-GTR-proto were conducted. As a result, fairly good repeatability and reproducibility of the Flex-GTR-proto, and comparability of the Flex-GTR-proto output under the symmetric right and left bumper corner impacts were observed (majorities of CV values are less than 3%).
As for the comparability between the Flex-GT and Flex-GTR proto, some differences were observed between them. Most of the maximum value ratios of Flex-GTR-proto relative to the Flex-GT are less than

1.1. The difference between the Flex-GT and Flex-GTR-proto has a chance to affect the injury threshold values; therefore, a following research has been investigating the threshold values for the Flex-GTR-proto using the ratios of the Flex-GT and Flex-GTR outputs and/or using the correlations between the Flex-GTR-proto and human lower extremities outputs which can be obtained from a computer simulation analysis.

Paper number 09-0262-O

The Scatter Of Pedestrian Upper-Leg Impactor

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Technical Session
Vulnerable Road Users: Pedestrian Safety

UTAC France

Abstract:
The pedestrian protection given by a vehicle is assessed according to four independent impact test procedures, related to different body segments. Four impactors were developed specifically: leg, femur (or upper-leg), child head and adult head. These impactors, which are thrown against specific zones of the front face of the vehicle, allow the measurements of biomechanical criteria simulating the injury risk during the impact Such test procedures are used by Euro NCAP and by the European regulation on pedestrian protection. Concerning the upper-leg impactor, two biomechanical criteria are analysed: the sum of force and the three femur bending moments. A specific study has been carried out on the scatter of upper-leg tests by PSA Peugeot Citroën in cooperation with UTAC in order to assess the scatter of this set of biomechanical criteria in different laboratories. In order to reduce the number of parameters of scatter and to isolate those linked to the upper-leg impactor, these tests have not been made on a full vehicle but on a simplified sub-system which permits to obtain biomechanical criteria very close to those obtained with a complete vehicle. Tests conditions of the upper-leg impactor (weight and speed) vary in protocols (Euro NCAP as well as regulation) according to the vehicle style. About forty tests have been carried-out in each laboratory according to two different impact energies and with two different upper-leg impactors. Results of those tests have enabled us to better understand and to quantify the scatter of the upper-leg impactor and to improve the design of our vehicles for the pedestrian protection.

Paper Number 09-0277-O

Evaluation Of A Flexible Pedestrian Legform Impactor (Flex-PLI) For The Implementation Within Legislation On Pedestrian Protection

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ika -Institut für Kraftfahrzeuge RWTH Aachen University, Germany

Abstract:
A flexible pedestrian legform impactor (FlexPLI) with biofidelic characteristics is aimed to be implemented within global legislation on pedestrian protection. Therefore, it is being evaluated by a technical evaluation group (Flex-TEG) of GRSP with respect to its biofidelity, robustness, durability, United Statesbility and protection level (Zander, 2008). Previous studies at the Federal Highway Research Institute (BASt) and other laboratories already showed good progress concerning the general development, but also the need for further improvement and further research in various areas (Zander et al., 2007). This paper gives an overview of the different levels of development and all kinds of evaluation activities of the Flex-TEG, starting with the Polar II full scale pedestrian dummy as its origin and ending up with the latest legform impactor built level GTR that is expected to be finalized by the end of the year 2009. Using the latest built levels as a basis, the paper reveals gaps that are recommended to be closed by future developments, like the United

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Statesge of an upper body mass (UBM), the validation of the femur loads, injury risk functions for the cruciate knee ligaments and an appropriate certification method. A recent study on an additional upper body mass being applied for the first time to the Flex-GT is used as means of validation of the lately proposed modified impact conditions by Konosu et al. (2007-2). Therefore, two test series on a modern vehicle front using an impactor with and without upper body mass are being compared. A test series with the Flex-GTR will be used to study both the comparability of the impact behavior of the GT and GTR built level as well as the consistency of test results. Recommendations for the implementation within legislation on pedestrian protection are made.

Paper Number 09-0376-O

Evaluation Of The Effectiveness Of Pedestrian Protection Systems Through In-Depth Accident Investigation, Reconstruction And Simulation

José Manuel Barrios, Andrés Aparicio, Arturo Dávila
IDIADA Automotive Technology SA, Spain
Juan Luis de Miguel, Sara Modrego Ana Olona
Centro Zaragoza, Accident Research and Traffic Safety, Spain
Alexandro Badea, Arturo Furones, Francisco Javier Páez
INSIA- UPM Accident Research and Vehicle Dynamics, Spain
José María Martín
SERNAUTO, Spain

Abstract:
New simulations are used to evaluate the benefits of these systems. The main conclusions are discussed, Around 15% of traffic accident casualties in accounting for the limitations of the study, which Europe are pedestrians. To date, most of the studies basically lie in the modelling of the Pedestrian carried out only provide statistical information on Detection Systems. the problem and few in-depth studies provide countermeasures which might correct it. The methodology proposed in this paper can be applied to other vehicle safety devices to evaluate There are many studies concerning pedestrian their effectiveness, based on the analysis of real protection, which can be grouped into 'pedestrian accidents. All the results presented here come from modelling', 'biomechanical limits for pedestrians' a project partly funded by the Spanish Ministry of and 'statistical analysis for pedestrian accidents'. Industry. Despite these studies, there is no predictive analysis of the benefits of pedestrian protection systems

Paper Number 09-0112-O

Development Of Flexible Pedestrian Legform Impactor FE Model And Comparative Study With Leg Behavior Of Human FE Model Thums

Hiroshi Miyazaki, Yuichi Kitagawa, Tsuyoshi Yasuki, Masaaki Kuwahara, Fumio Matsuoka
Toyota Motor Corporation, Japan

Abstract:
The current legform impactor in pedestrian safety tests uses a steel shaft connected to metal

plates to represent the femur and tibia. It evaluates leg fracture risk based on tibia acceleration, and knee ligament rupture risk based on knee bending angle and shear displacement. However, the impactor does not generate the tibia deflection that occurs when a vehicle impacts a pedestrian. The new flexible pedestrian legform impactor (Flex-PLI) currently under development is designed to simulate the impact behavior of the human leg, reproducing tibia deflection with flexible shafts and representing the knee ligaments using wires. As a result, it can be used to help assess injury based on deformation by estimating the risk of tibia fracture from the bending moment of the tibia shaft and the risk of knee ligament rupture from the elongation of the wires. In this study, a finite element (FE) model of the Flex-PLI was developed to examine the impact test protocol for pedestrian leg injury assessment, comparing the impactor behavior and response with that of a whole human FE model. The Flex-PLI FE model was created by reverse engineering that reproduced the shape and mechanical properties of each part. The impact velocity of the impactor was set to 40 km/h based on accident data. An impact height of 75 mm above the ground has been proposed for the Flex-PLI in contrast to the current protocol, which specifies an impact height of 0 mm. The study compared results at the base impact height of 75 mm with those obtained at different heights. It also investigated the effect of adding mass to simulate the upper body of a pedestrian. Vehicle-to-pedestrian impact simulations were conducted with the Total Human Model for Safety (THUMS) to estimate the behavior and response of a human leg for comparison with the results from the impactor model. The bending moment of the tibia and the elongation of the knee ligament wires in an impact varied depending on the impact height and additional mass. Impactor behavior was closest to THUMS at a height of 0 mm, but a closer response to THUMS for bending moment and ligament elongation was obtained at 75 mm. It was also found that adding a mass of 6 kg to the upper end of the impactor in SUV impacts created a closer response to THUMS.

Paper No. 09-0318-O

Performance Of Vehicle Bumper Systems With The EEVC/TRL Pedestrian Lower Legform

Ann Mallory
Transportation Research Center Inc.
Jason Stammen
National Highway Traffic Safety Administration, United States

Abstract:
In U.S. pedestrian crashes, serious lower extremity injuries are second only to head injuries in frequency. The Global Technical Regulation (GTR) for pedestrian safety uses the EEVC/TRL pedestrian lower legform to evaluate the risk of these injuries from bumper impact. In order to evaluate the level of pedestrian lower extremity protection offered by front bumpers in the U.S. fleet, NHTSA's Vehicle Research and Test Center (VRTC) conducted 40 pedestrian lower legform impact tests on 9 vehicles. These vehicles were selected to represent the U.S. fleet, with a focus on light trucks and vans. The goal was to generate an overall picture of current U.S. vehicle performance with respect to lower extremity protection requirements in the regulation. Results showed that pedestrian lower extremity protection was poor overall, with no vehicle meeting the GTR injury limits in all locations tested. One vehicle was able to meet the requirements by a wide margin in all but one impact location. Two other vehicles each had a

single passing impact location. Results are consistent with prior results from legform testing on U.S. passenger cars.

Paper Number 09-0206-O

Characteristics of the TRL Pedestrian Legform and the Flexible Pedestrian Legform Impactors in Car-front Impact Tests

Yasuhiro Matsui, Shunsuke Takagi, Yoshitomo Tanaka, Naruyuki Hosokawa, Fujine Itoh, Hideto Nakasato, Noriaki Watanabe, Hideki Yonezawa
National Traffic Safety and Environment Laboratory, Japan

Abstract:

Pedestrian protection is one of the key topics of discussion in the area of vehicle safety legislation in Europe and Japan. Leg injuries are the most common injuries found in nonfatal pedestrian accidents. The EC regulation and Euro NCAP are evaluating pedestrian leg protection performance in current vehicles. The TRL legform impactor is specified by the EC regulation, where Phase 1 took effect during 2005 and a draft phase 2 is scheduled to take effect in 2013. The global technical regulation (GTR) pedestrian protection test protocol was made basically using the TRL legform impactor. However, a flexible legform impactor has been under development. When the flexible legform impactor development is fully completed and evaluated, it is possible that both legform impactors may be determined to be useful in the GTR. Thus, the objective of this study is to investigate the characteristics of pedestrian leg protection performance of the frontal area of current vehicles using the TRL legform impactor and the flexible legform impactor. Different types of vehicles (sedan, sport utility vehicle (SUV), height wagon, and 1 box car) were used. The center of the bumper and center of the side members (i.e., the vehicles main longitudinal beams) were selected as impact locations for the legform impactors tests. This paper discusses an equivalence of injury assessment between the TRL legform impactor and flexible legform impactor.

Paper Number 09-0459-O

The Causes Of Pedestrians' Head Injuries Following Collisions With Cars Registered In 2000 Or Later

David Richards, Rebecca Cookson, Richard Cuerden
TRL
Gareth Davies
Helicopter Emergency Medical Service, United Kingdom

Abstract:

Injury and collision data from London's Helicopter Emergency Medical Service (HEMS) and the UK's Police fatal files were used to quantify and describe the nature of pedestrian head injury and investigate the causes.

The HEMS data relating to all pedestrian accidents since 2000 was analysed with respect to their injuries, and the cost of these injuries was estimated using the time they spent on the ward and/or in intensive care. In addition to the HEMS data, Police fatal files containing details of fatal

pedestrian impacts with the front of cars registered in 2000 or newer were analysed. These included post-mortems, which were coded using the Abbreviated Injury Scale. Although the fatal file sample was limited in size, it had the advantage of containing photographs of the accident and many other pertinent details. This enabled the causes of individual injuries to be determined. The head injuries seen in the HEMS data were then compared to the injuries in the fatal files.
The HEMS dataset contained 746 pedestrians struck by motor vehicles, with 2,974 recorded injuries. 34 fatal pedestrian accidents were analysed using the Police fatal files.
The analysis of the HEMS data showed that the most frequent and costly injuries were to the head and legs. Head injuries of fatally injured adults were found to be principally caused by contact with the windscreen and surrounding structure.
This research highlights the potential of hospital data to be an important tool in accident research, as the injury information can provide evidence of the effects of the changing vehicle fleet, and what injuries should be prioritised in the future. The paper also begins to quantify the proportion of the most serious head injuries (suffered by fatalities) which are caused directly by the vehicle, compared with secondary impacts with the ground or other objects.

Paper Number 09-0127-O

Pedestrian Head Impact Dynamics: Comparison Of Dummy And PMHS In Small Sedan And Large SUV Impacts

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Carlos Arregui
European Center for Injury Prevention, Universidad de Navarra, Spain

Abstract:
This study compares head impact dynamics between post mortem human surrogates (PMHS) and the Polar-II pedestrian crash dummy in vehicle-pedestrian impacts with a small sedan and a large SUV. A total of fifteen (8 sedan, 7 SUV) full-scale vehicle pedestrian impact tests were performed at 40 km/h. For each vehicle, two (SUV) or three (sedan) PMHS tests and five dummy tests were performed, with three of the dummy tests in the same configuration to show repeatability, and the other two tests utilizing slightly different configurations. Head linear and angular kinematics were captured from PMHS and dummy head instrumentation, and dummy neck forces and impact forces were calculated from the upper neck load cell data. Differences in head impact locations, timing, and kinematics between the dummy and PMHS were minimized when the dummy was positioned higher above the ground reference level to match the pelvis height of the PMHS. On average, the dummy recorded higher resultant impact forces (2930 N vs. 1862 N) in windshield impacts to the sedan than in hood impacts to the SUV, which resulted in higher HIC15 values and higher peak and averaged angular accelerations. While differences in dummy injury risk metrics both the dummy and PMHS data show that the difference in injury risk metrics predicted by the dummy can be explained by the variation in impact velocity between the sedan (14.1 ± 1.2 m/s) and the SUV (10.7 ± 2.3 m/s), the differences in injury risk predicted by the PMHS is not as clear due to confounding factors. The data and analyses presented in this study also show that neck forces during head impacts contribute a substantial and additive effect to the head impact accelerations (and thus HIC15

values) measured in the dummy, and that for the SUV, neck forces affect head accelerations more than impact forces. Despite analyzing only lateral impacts with two vehicle geometries at 40 km/h, this study provides the only comparison of PMHS and dummy pedestrian head impact kinematics data available.

Paper number 09-0026-O

Development Of An Hybrid Hood To Improve Pedestrian Safety In Case Of vehicle Impact

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Abstract:
In recent years car manufacturers when developing new car designs have paid great attention to two main aspects. On one hand there are the pollutant emissions and in particular the carbon dioxide emissions which are directly connected to the fuel consumption of cars, on the other hand there is the always increasing safety level required for the cars, with a particular attention to the safety of pedestrian and other vulnerable road users (VRU). The present paper reports some results of a recent research activity developed in this perspective and specifically devoted to the design of a bonnet for a middle/low segment car. A global overview on the different solutions which can be used to obtain a lightweight and pedestrian safe bonnet will be illustrated. The main part of the work deals with the design of a hybrid metal/plastic bonnet. All the aspects examined during the design of a new bonnet will be taken into consideration, starting from the technical performance and going through the manufacturing and economical aspects. Then some considerations on a bonnet with a peripherical frame solution will be presented. At the end, the study on a further concept of hybrid bonnet characterized by a particular wire design of the inner structure will be addressed.

Paper Number 09-0067-O

Development Of The Pop-Up Engine Hood For Pedestrian Head Protection

Yusuke Inomata, Nobuhiro Iwai, Yoshinori Maeda,
Seiichi Kobayashi, Hiroyuki, Okuyama, Nobuhiko Takahashi
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Abstract:
The “Pop-up Engine Hood” helps makes it possible for automobile designers to help reduce head injury during pedestrian impact while maintaining streamlined hood design. Some countries have adopted pedestrian protection regulation and there is an on-going discussion in the United Nations WP29 about Global Technical Regulations (gtr) and there is a possibility such regulations may be enhanced in the future. Many car manufacturers have been planning to improve pedestrian safety by various technical applications. In general, pedestrian head protection is achieved by creating space between the hood (which is deformable) and the

engine component (which is not). However, this concept is difficult to apply to some vehicles, especially low engine hood vehicles, such as coupes and sport cars. The “Pop-up Engine Hood System” which has recently been used in mass production vehicles in Japan may help with this issue. This paper will describe the system outline and key technologies incorporated in the system e.g.:

- Effectiveness of injury reduction mechanism (evaluated using CAE analysis and tests) when a pedestrian contacts directly above or near the actuator, which lifts up the hood.
- Technique to help reduce the dispersion of head injury due to hood vibration during the hood raising process.
- Human kinematics during system operation evaluated by using Polar-II dummy (currently available as a pedestrian full scale dummy), and human body FE model.

Paper Number 09-0366-O

Effect Of Muscle Contraction In Low Speed Car-Pedestrian Impact – Simulations For Walking Posture

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Rajesh Malhotra
Department of Orthopaedics, All India Institute of Medical Sciences, Delhi, India

Abstract:
This paper investigates the effect of muscle contraction on lower extremity injuries in low-speed car-pedestrian lateral impacts for a walking pedestrian. The full body model, PMALE, which was configured in symmetric standing posture, has been repositioned in the walking posture. FE simulations have then been performed for its impact with the front structures of a car. Two impact configurations, i.e. impact on the right and on the left leg have been simulated. Two pre-impact conditions that of a symmetrically standing pedestrian, representing a cadaver and an unaware pedestrian have been simulated for both the impact configurations. Stretch based reflex action was modeled for the unaware pedestrian. It is concluded that (1) with muscle contraction, risk of ligament failure decreases whereas risk of bone fracture increases (2) in lateral impacts, MCL could be considered as the most vulnerable and LCL as the safest ligament and (3) for a walking pedestrian, PCL would be at a higher risk in case of impact on rear leg whereas, in case of impact on front leg, ACL would fail.

Keywords: PMALE, Lower extremity model, Finite element model, Dynamic simulation, Muscle contraction, Standing posture, Walking posture, Car-pedestrian impact, Knee injury

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Paper Number 09 –0462-O

Safety Requirements For Cyclists During Car Impacts To The Legs

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Technical Session
Vulnerable Road Users: Pedestrian Safety

Abstract:
The term vulnerable road user (VRU) is most commonly associated with pedestrians and in particular children and the elderly. In many European countries cyclists make up a significant number of VRU casualties – typically around one-third. In the context of the European 6th Framework Integrated Project APROSYS (Advance PROtection SYStems), a study was conducted to examine the safety requirements for cyclists and whether these were addressed by current pedestrian safety assessments of cars.
An examination of accident statistics was first conducted to determine the principal accident scenarios for cyclists. Since insufficient cyclist cases were recorded in a detail database of VRU accidents compiled during APROSYS, a programme of virtual testing was then conducted. The objective was to identify the most significant parameters during cyclist impacts with a range of cars sizes and the likely injury consequences. The primary region of investigation was impacts to the legs and knees – the points of first contact.
The study indicated that cyclists interacted differently with cars than pedestrians, resulting from the geometric configuration of their legs, the presence of the bicycle and their elevated riding position. The potential for injury was different and the current sub-system impactor tests used by Euro NCAP and for vehicle certification purposes did not address all these differences. It was determined that the relevance of the current pedestrian impact safety assessments of cars for cyclists could be improved by minor changes to the test parameters. However, the study also identified new injury mechanisms that may require further biomechanical investigations.
Although this study has considered a wide range of cyclist impact configurations it should not be considered as definitive. Further work including physical testing is needed in order to take forward improved safety test procedures.

Paper Number 09-0485-O

Development And Validation Of Pedestrian Sedan Bucks Using Finite Element Simulations; Application In Study The Influence Of Vehicle Automatic Braking On The Kinematics Of The Pedestrian Involved In Vehicle Collisions

Costin Untaroiu, Jaeho Shin Jeff Crandall
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Rikard Fredriksson Ola Bostrom
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Yukou Takahashi, Akihiko Akiyama, Masayoshi Okamoto,
Yuji Kikuchi
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Abstract:
Previous vehicle-to-pedestrian simulations and experiments using pedestrian dummies and cadavers have shown that factors such as vehicle shape, pedestrian anthropometry and pre-impact conditions influence pedestrian kinematics and injury mechanisms. Generic pedestrian bucks, that approximate the geometrical and stiffness properties of current vehicles, would be useful in studying the influence of vehicle front end structures on pedestrian kinematics and loading. This study explores the design of pedestrian bucks, intended to represent the basic vehicle front-end structures, consisting of five components:

lower stiffener, bumper, hood leading edge and grille, hood and windshield. The deformable parts of the bucks were designed using types of currently manufactured materials, which allow manufacturing the bucks in the future. The geometry of pedestrian bucks was approximated based on the contour cross-sections of two sedan vehicles used in previous pedestrian dummy and cadaver tests. Other cross-sectional dimensions and the stiffness of the buck components were determined by parameter identification using FE simulations of each sedan vehicle. In the absence of a validated FE model of human, the FE model of the POLAR II pedestrian dummy was used to validate a mid-size sedan (MS) pedestrian buck. A good correlation of the pedestrian dummy kinematics and contact forces obtained in dummy - MS pedestrian buck with the corresponding data from dummy - MS vehicle simulation was achieved. A parametric study using the POLAR II FE model and different buck models: a MS buck and a large-size sedan (LS) buck were run to study the influence of an automatic braking system for reducing the pedestrian injuries. The vehicle braking conditions showed reductions in the relative velocity of the head to the vehicle and increases in the time of head impact and in the wrap-around distances (WAD) to primary head contact. The head impact velocity showed greater sensitivity to the different buck shapes (e.g., LS buck vs. MS buck) than to the braking deceleration. The buck FE models developed in this study are expected to be used in sensitivity and optimization studies for development of new pedestrian protection systems.

Oral Presentations

Technical Session
Advances in Vulnerable Occupant Protection Systems

Oral Presentations | Thursday, June 18th, 2009 | TRACK B | Room C5

Time: 09:00-12:30

Chairperson: Jerzy W. Kownacki, Poland
Co-Chairperson: Donald MacDonald, United Kingdom

Paper Number 09-0242-O

Responses of Hybrid III 3YO and Q3 Dummies in Various CRSs Tested Using ECE R44 Impact Conditions

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Abstract:
There are various types of child restraint systems (CRSs), and the child kinematic response behavior during a crash is different according to which CRS type is being used. In general, P3, Q3 and Hybrid III 3-year-old (3YO) dummies are used to evaluate the performance of the forward-facing CRSs in sled and crash tests. In this study, the Hybrid III 3YO and Q3 dummies were seated in 7 types of CRSs and were tested under the impact conditions specified in ECE R44. The tested CRSs include a 5-point harness and an impact shield, and their installations on the vehicle seat were accomplished by using the seat belt or the ISOFIX with a top tether. The dummy response and injury measures were compared.
The neck flexed in the 5-point harness CRS and the chest deflection was small due to the shoulder harness restraint. In the impact shield CRS, the chest was loaded and the chest deflection was large. The chest deflection in the impact shield CRS depends on the shield structure, and it was small when the shield supported the pelvis. For the 5-point harness CRS, the injury measures of the dummy were smaller in the ISOFIX CRS with a top tether than in the seat belt installed CRS, especially that for the head excursion. For the impact shield CRS, the injury measures were comparable between the ISOFIX CRS with a top tether and in the seat belt installed CRS.
The global dummy kinematic behavior was comparable between the Hybrid III 3YO and Q3 dummies, though the Q3 showed more flexible behavior. This less-stiff characteristics of the Q3 affected the head kinematic behavior. In the 5-point harness CRS, the neck tension force of the

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Q3 was higher than that for the Hybrid III 3YO, possibly because the Q3 head severely contacted the chest due to its less-stiff neck. The chest deflection of the Q3 was larger than that of Hybrid III 3YO. This large chest deflection was more prominent for the impact shield CRS where the chest was directly loaded. The bottoming-out of the chest occurred for the Hybrid III 3YO seated in the impact shield CRS. .

Paper Number 09-0564-O

The Role Of Vertical Roof Intrusion In Predicting Occupant Ejection

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Abstract:
The purpose of the current study is to investigate whether there was a statistically significant relationship between vertical roof intrusion and the probability of occupant ejection in rollovers that are likely to be covered by Federal Motor Vehicle Safety Standard No. 216 (FMVSS No. 216). If such a relationship did exist, FMVSS No. 216 might affect the number of occupant ejections in rollovers.
The study applies thirty six different statistical models to crash data to model the probability of occupant ejection using a number of explanatory variables, including the amount of vertical roof intrusion. The data is on vehicle occupants who were involved in relevant rollover crashes, and is taken from NASS CDS for years 1997 to 2006 (n = 5,562). Though the study considers a number of different models, it does not find a statistically significant relationship between vertical roof intrusion in relevant rollovers and the probability of complete occupant ejection. When ejections of any degree are considered (whether complete, partial, or of unknown degree), there was a statistically significant relationship in some subpopulations.
Given that no relationship has been found between the amount of vertical roof intrusion and the probability of complete occupant ejection, increasing roof strength is unlikely to impact the number of complete occupant ejections. The study is limited to occupants in rollovers that are likely to be covered by FMVSS No. 216, and to occupants for whom key data, such as the amount of vertical roof intrusion, are available.

Paper Number 09-0355-O

Safer Child Restraints For Children 6 To 10 Years

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Road Safety Solutions, Australia
Julie Brown
Prince of Wales Medical Research Institute, Australia
Paul Kelly
Road Safety Solutions, Australia

Abstract:
Other studies have identified, and recent studies in Australia and the U.S. have confirmed, that whilst the 1970's concept of boosters to try to improve adult seatbelt geometry for growing children is a good one, many of the currently available boosters do not provide

children with optimal restraint.
This paper recommends a new category of CRS booster with the intention of providing more effective restraint to children in the 6 to 10 age group.
Recommended features include:-
-a mandatory requirement for side wings with performance based requirements. -lap belt guides -sash belt guides -top tether strap -anti-submarining features -that the base of the booster seat be narrower so that three of these child restraints can fit across the rear seat of a typical mid size car's rear bench seat and allow for arm rests from car doors
-the seat incorporate 'ride height' lines.
Furthermore, this category of booster should have more demanding assessment procedures to ensure booster seats coming onto the market actually achieve improved protection for the children using them.
What this paper offers that is new is a safer class of booster to take older children through till they safely fit an adult seatbelt.
This paper explains the need for each component and shows the suggested dimensions of an exemplar restraint.

Paper Number 09-0367-O

A Study Of Thoracic Injury Criteria For Elderly Korean Occupant

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Abstract:
According to 2005 national census, more than 65 year older population is about 10% of total 48millions population. In 2030, the elderly rate will be reached up to 23%. The statistical analysis of elderly traffic accident from the national policy report, the elderly fatalities was 2,183 (33.3% of 6,563) in 2004. This was the double increase compared with 14 year years ago. In 1994, elderly fatality was 1,748 (17.3%). Elderly driver and passengers have a disproportionately higher crash involvement rate and commonly sustain more severe injuries than the other generation.
The current frontal impact regulation of Korean safety standard (KMVSS 102) is based on the FMVSS 208 to protect the motor vehicle occupant in the event of frontal crash type accidents. The injury criteria utilized in the regulation is based on 50%tile Hybrid III dummies in both driver and passenger sides. Therefore, no motor vehicle standards in Korean are designed to specially address the needs of elderly persons. Since the elderly population is rapidly increasing, it is more important to improve the safety standard to mitigate elderly casualties.
A primary objective of the study is to develop a guideline or standard for elderly occupants protection with new injury criteria on the frontal impact regulation and to promote design of

restraint system or so call silver vehicle for elderly in the domestic market. The physical characteristics of elderly Korean occupant are relatively small and lighter than that of western elderly. Data from the SizeKorea database (total surveyed number of subjects in SizeKorea database was 14,200 between 0 to 90 years old), the 50th %tile height and weight of the subjects in target group (527 male samples) were 162.8cm and 62kg, respectively.
From the in-depth study of recent years vehicle-tovehicle frontal crash accidents, the elderly occupant sustain more thorax rib fracture injury within MAIS
<2. More than MAIS >3 case, elderly suffers more hemo/pneumo thorax injury than younger occupant.
In this study, as an assessment tool with scaling methods 50%tile Korean elderly Hybrid III type simulation model was developed to mitigate elderly thorax injury.

Paper Number: 09-0410-O

Opportunities for Protecting the Right Front Passenger in Frontal Crashes

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Abstract:
This paper explores opportunities to better protect belted right front passengers during frontal crashes. Paired comparisons of using NASS CDS 2000-2007 data showed that, across all ages and genders, belted passengers carried a 34% higher serious injury risk than belted drivers. In an effort to explain this difference, we explore crash configurations where right front passengers most often sustain serious injuries. We also identified primary attributes of right front passengers including age and weight to determine how they differ from drivers when serious injuries occur.
When involved in the same crash, right front passengers more often sustain MAIS3+ injuries compared to drivers. However, there are fundamental differences between these populations. First, a higher percentage of right front occupants are injured during angled collisions with a 1 o'clock principle direction of force. These crashes are more serious for occupants seated on the nearside or passenger side of the vehicle. Often these crashes occur at intersections where the struck vehicle initiates a turn.
A second reason for this difference in risk is principally due to the presence of occupants in the passenger location who are more vulnerable to injury than the driver. While only 1 in 10 right front seat occupants involved in frontal crashes are age 65 and older, the elderly population makes up more than 1/3 of the MAIS3+ injured group. When both front seat occupants are elderly, the most vulnerable in terms of age or gender is in the passenger position 85% of the time. The GES data showed that when two elderly occupants (age 65+) were present, the female occupied the right front passenger position 73% of the time.
Analysis of NASS GES data suggests that, when an elderly male occupies the passenger seat he is frequently older than the driver. When investigated further, there was no significant difference in the fatal injury risk of young belted drivers and young belted right front passengers

in frontal crashes.

Paper Number 09-0351-O

Misuse Of Airbag Deactivation When Children Are Travelling In The Front Passenger Seat

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Abstract:
Within the process of integrating passenger airbags in the vehicle fleet a problem of compatibility between the passenger airbag and rearfacing child restraint systems was recognised. Especially in the US several accidents with children killed by the passenger airbag were recorded. Taking into account these accidents the deactivation of a present passenger airbag is mandatory if a child is carried in a rearfacing child restraint system at the front passenger seat in all member states of the European Union. This rule is in force since the deadline of 2003/20/EC at the latest.
In the past a passenger airbag either could not be disabled or could only be disabled by a garage. Today there are a lot of different possibilities for the car driver himself to disable the airbag. Solutions like an on/off-switch or the automatic detection of a child restraint system are mentioned as an example. Taking into account the need for the deactivation of front passenger airbags two types of misuse can occur: transportation of an infant while the airbag is (still) enabled and transportation of an adult, while the airbag is disabled, respectively. Within a research project funded by BASt both options of misuse were analysed utilising two different types of surveys amongst users (field observations and interviews, Internet-questionnaires). In addition both analysis of accident data and crash tests for an updated assessment of the injury risk caused by the front passenger airbag were conducted.
Both surveys indicate a low risk of misuse. Most of the misuse cases were observed in older cars, which offer no easy way to disable the airbag. For systems, which detect a child seat automatically, no misuse could be found. The majority of misuses in cars equipped with a manual switch were caused by reasons of oblivion.

Also the accident analysis indicates a minor risk of misuse. From more than 300 cases of the GIDAS accident sample that were analysed, only 24 children were using the front passenger seat in cars equipped with a front passenger airbag. In most of these cases the airbag was deactivated. When misuse occurred the injury severity was low. However, when analysing German single accidents the fatality risk caused by the front passenger airbag became obvious. From the technical point of view, there were important changes in the design of passenger airbags in recent years. Not only volume and shape were modified, but also the mounting

position of the entire airbag module was changed fundamentally.
Even if these findings do not allow obtaining general conclusions, a clear tendency of less danger by airbags could be identified. For future vehicle development a safe combination of airbags and rear faced baby seats seems to be possible in the long term. This would mean that both types of misuse could be eliminated. For parents an easier use of child seat and car would be the result.

Paper Number 09-0044-O

Continuous Restraint Control Systems: Safety Improvement For Various Occupants

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Abstract:
Occupant safety can be significantly improved by continuous restraint control systems. These restraint systems adjust their configuration during the impact according to the actual operating conditions, such as occupant size, weight, occupant position, belt United Statesge and crash severity. In this study, the potential of a controlled restraint system is demonstrated. First, an overview is given of the problems concerning the sensors, actuators and control strategy of such a system, and solutions are given. Next, a numerical demonstrator is developed, which includes a dummy and vehicle model, and a realistic implementation of the components of the controlled restraint system. The demonstrator is subjected to different loading conditions, and the results are compared to a reference model. This reference model contains a conventional restraint system with optimized settings, and it has been validated against sled test experiments. Simulation results with the demonstrator indicate that significant injury reduction can be achieved with continuous restraint control systems.

Paper Number 09-0414-O

Protection Of Overweight Children In Child Restraint Systems

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Abstract:
According to the German road traffic regulations children up to the age of 12 or a body height below 150 cm have to use approved and appropriate child restraint systems (CRS). CRS must

be approved according to UN-ECE Regulation No. 44. The regulation classifies CRS in 5 body weight categories. The upper weight group is approved for children from 22 to 36 kg. However, studies show that already today many children weigh more than 36 kg although they have not reached a size of 150 cm. Therefore, no ECE R44 approved CRS is available for these "overweight" children. In conclusion, today's sizes and weights of children are no longer represented by the current version of the ECE R44. The heaviest used dummy (P10) weighs just
32.6 kg and has a body height of 137.9 cm. Statistical data of German children show that already 5% of the children at a size of 137.9 cm have a body weight above 45.3 kg. Regarding children at a body height of 145 cm, the 95th percentile limit is at a weight of 53.3 kg. Based on these data 4 dummies with different heights and weights were defined and produced. Two of them are "overweight". Up to now, there is no experience how current child restraint systems perform in a car crash if they are used by children with a body weight above 36 kg and a size smaller than 150 cm. In the future, different child restraint systems will be tested with respect to the ECE R44 regulation using these "overweight" dummies.

Paper No 09-0354-O

A Safe Ride Height Line For Child Car Occupants

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Michael Paine
Vehicle Design & Research, NSW, Australia, Australia

Abstract:
Studies of child occupant safety in cars in have consistently reported that one of the biggest problems with unsafe use of child restraints is premature graduation of children into restraint systems that the intended for older children.
In 2007 our team conducted a study to identify ways of ensuring that children travel in the safest restraint for their age and size. The outcome of the review was subsequently included in revisions to Australian road rules.
During the study we identified the potential for the concept of a 'safe ride height' line. That is, the child restraint systems, and vehicles in which they travel, could both be clearly marked with a 'safe ride height' line to be used to indicate whether a child was an appropriate size for the restraint.
The 'safe ride height' line could be integrated prospectively and retrospectively across the full width of the seat back of the vehicle. If a child's shoulders are below the line, the child is too small for an adult seatbelt.
In child restraints, the 'safe ride height' lines can be tailored for each type of restraint system. For example, in a forward facing child seat, there could be a lower 'safe ride height' line for a child who has just grown big enough, and an upper 'safe ride height' line for a child who now needs to graduate out of the restraint.
'Safe ride height' lines are included in the current draft for a revised Standard for child restraint systems in Australia.

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What this paper offers that is new is the concept of a 'safe ride height' line that will provide an easy guide for carers as to the appropriate size restraint for a child and allow simple self evident enforcement of correct restraint United Statesge rules.

Paper No. 09-0539-O

NHTSA's Initial Evaluation Of Child Side Impact Test Procedures

Lisa K. Sullivan, Allison E. Louden
National Highway Traffic Safety Administration, United States

Abstract:
This paper details the National Highway Traffic Safety Administration's (NHTSA) initial research to evaluate potential child side impact test procedures. Federal Motor Vehicle Safety Standard (FMVSS) No. 213, "Child Restraint Systems" currently only requires that U.S. marketed child restraints meet dynamic testing simulating a 48.3 kph (30 mph) frontal impact. NHTSA is evaluating test parameters and potential methodologies to replicate a representative side impact scenario that could potentially be developed into a future child restraint dynamic side impact test procedure. This paper will discuss (1) testing conducted using the side impact sled buck designed by TK HOLDINGS INC. (Takata), and (2) side impact moving deformable barrier (MDB) into vehicle crash tests, which were performed in an effort to refine sled buck test parameters. This study is limited to one generic sled test buck design concept and side impact tests involving small passenger vehicles. It was observed that the sled buck concept was repeatable and able to distinguish between child restraint system (CRS) models. The design of the CRSs' seat back side wing is an important element for providing side impact protection, particularly when impact angles are varied. Trends in injury response values between sled and crash tests were similar for the two CRS models used in both types of testing.

Paper Number 09-0358-O

Development And Improvement Of Q3s – A Three Year Old Child Side Impact Dummy

Zhenwen J. Wang, Cheng Yao, Eric Jacuzzi, Karthik Marudhamuthu
First Technology Safety Systems, Inc., United States

Abstract:
The research of child restraint systems tested under side impact test conditions has been conducted extensively in the past few years. In May 2008 US Government and Industry meeting, US National Highway Traffic Safety Administration (NHTSA) presented a summary of the 3 year old child side impact dummy evaluation result with some desired improvements, including the neck biofidelity and thorax rib cage durability. With further evaluation later at Ford, Transport Canada and NHTSA Vehicle Research and Test Center (VRTC), it was observed the hip ball popped out from the cup retainer during some of the tests. The overall biofidelity of this dummy was summarized by Carlson et al, and also

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updated biofidelity summary was presented by Rhule [3] in 2008 Government Industry meeting. This paper summarizes the improvements that address these identified issues in the past year.

Oral Presentations

Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Oral Presentations | Thursday, June 18th, 2009 | TRACK C | Room C7

Time: 09:00-12:30
Chairperson: Matolcsy Mátyás, Hungary
Co-Chairperson: Steve Sopp, United Kingdom

Paper Number 09-0072-O
Anti Lock Braking And Vehicle Stability Control For Motorcycles – Why Or Why Not?

Jost Gail
Federal Highway Research Institute, Germany
Joachim Funke
Fludicon GmbH
Germany
Patrick Seiniger
Technische Universität Darmstadt, Fachgebiet
Fahrzeugtechnik, Germany
Ulrich Westerkamp
Institute for Transport Economics at the University of Cologne, Germany

Abstract:
In the last years there has been a decline in accident figures in Germany especially for four wheeled vehicles. At the same time, accident figures for motorcycles remained nearly constant. About 17 % of road traffic fatalities in the year 2006 were motorcyclists. 33 % of these riders were killed in single vehicle crashes. This leads to the conclusion that improving driving dynamics and driving stability of powered two wheelers would yield considerable safety gains. However, the well-known measures for cars and trucks with their proven effectiveness cannot be transferred easily to motorcycles. Therefore studies were carried out to examine the safety potential of Anti Lock Braking Systems (ABS) and Vehicle Stability Control (VSC) for motorcycles by means of accident analysis, driving tests and economical as well as technical assessment of the systems. With regard to ABS, test persons were assigned braking tasks (straight and in-curve) with five different brake systems with and without ABS. Stopping distances as well as stress and strain on the riders were measured for 9 test riders who completed 105 braking manoeuvres each. Knowing the ability of ABS to avoid falls during braking in advance of a crash and taking into account the system costs, a cost benefit analysis for ABS for motorcycles was carried out for different market penetration of ABS, i.e. equipment

rates, and different time horizons. The potential of VSC for motorcycles was estimated in two steps. First the kinds of accidents that could be prevented by such a system at all have been analysed. For these accident configurations, simulations and driving tests were then performed to determine if a VSC was able to detect the critical driving situation and if it was technically possible to implement an actuator which would help to stabilise the critical situation.

Paper Number 09-0238-O

Mainland European Truck Accidents In The UK - Key Issues For Drivers

Russell Danton, Alan Kirk, Julian Hill
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Abstract:

The native UK vehicle fleet is right hand drive (RHD) with a corresponding road infrastructure, presenting unique challenges to the increasing numbers of mainland European left hand drive (LHD) heavy goods vehicles (HGVs) using UK roads. This paper analyses the nature and circumstances of HGV accidents in the UK, paying particular attention to LHD HGVs and the caUnited StatesI factors exhibited.

Using in-depth real world accident data the characteristics of 65 LHD HGVs involved in accidents are described in comparison with 250 RHD HGVs. On-scene cases from the UK 'On The Spot' (OTS) project, funded by the UK Department for Transport and Highways Agency, enable a detailed examination of accident caUnited Statestion mechanisms and behavioural patterns. Comparison is made with the national accident data to put the in-depth investigation into context.

The majority of LHD HGV collisions include caUnited StatesI factors related to vehicle geometry (blind spots) and driver mental load, compared to RHD HGV collisions which include injudicious and road environment factors. Discussion focuses on the complex, multifactorial nature of these accidents with both vehicles and drivers not best adapted for UK roads. Key aspects of the accidents studied are identified and their implications are discussed for enhanced driver support and education.

There are inevitable limitations regarding the amount of detail that can be collected on-scene due to the time consuming nature of the specialist vehicle examinations required and the language barrier. A pilot, translated, interview procedure has however been put in place to gain the maximum amount of information.

Paper number 09-0190-O

Implementation Of Stability Control For Tractor trailers Using The National Advanced Driving Simulator

Alrik L. Svenson, Paul A. Grygier
National Highway Traffic Safety Administration, United States
M. Kamel Salaani
Transportation Research Center, Inc.

Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Gary J. Heydinger
The Ohio State University
Timothy Brown, Chris Schwarz
National Advanced Driving Simulator United States

Abstract
Truck manufacturers are introducing Roll Stability Control (RSC) and Electronic Stability Control (ESC) systems on heavy trucks including tractor-trailer type vehicles. These systems are designed to assist a driver to avoid rollovers, and in the case of ESC, yaw instability in tractor-trailers. This paper reports on the implementation of stability control systems on the National Advanced Driving Simulator (NADS) for studying their effectiveness in mitigating tractor-trailer directional loss of control and rollover instability. Five driving scenarios were modeled to closely correspond to severe real-world driving situations. These included exit ramps, decreasing radius curves, and avoidance maneuvers. These were modeled using dry pavement and a snow-covered road surface. The simulator model was validated with actual test track data. This research provides a means to obtain simulator test data on drivers behavior in a tractor-trailer equipped with RSC and ESC during severe driving maneuvers which is new in this field of study. This paper describes the implementation of stability control systems on the NADS and validation of the NADS stability control model by NHTSA. Also, a brief overview of the experimental procedures and the designed driving scenarios used in the NADS study are given. Results of the validation indicate that the simulator study should provide data similar to what would be expected in actual vehicles, but due to limitations in the current NADS truck model it may not be possible to make direct comparisons of speeds achieved in maneuvers with an actual truck on a test track.

Paper Number 09-0097-O

Commercial Vehicle Safety Technologies: Applications For Brake Performance Monitoring

Deborah Freund
Federal Motor Carrier Safety Administration, United States
Douglas Skorupski
Booz Allen Hamilton Inc., United States

Abstract
A brake system deficiency is the most common reason for a commercial motor vehicle (CMV) to be cited for a regulatory violation and to be taken out-of service during a roadside inspection. As part of a major safety technology project intended to assess the state of the practice and potential contributions of advanced sensor systems, the Federal Motor Carrier Safety Administration (FMCSA) sponsored two studies on CMV brakes and related controls. The first study compared the performance of six types of brake systems and component sensors in a controlled, test-track environment under both nominal operating conditions and conditions where brake faults were deliberately introduced. The results indicated that all types of sensors tested (two different Hall-effect stroke sensors, anchor pins instrumented with strain gauges,

embedded thermocouples, ABS wheel-speed sensors, linear potentiometers, and a pressure transducer) provided useful information on brake performance status. However, their accuracy and fault-detection properties varied considerably, influencing their potential use in operational settings. The second study assessed the performance and maintainability of brake monitoring devices in an urban transit fleet. Twelve test and 12 control transit buses were fitted with 3 brake performance monitoring (BPM) systems. The buses accumulated more than 1.2 million kilometers in aggregate, during a 12-month test period. In operational use, it was demonstrated that commercially available sensors can be used to improve the effectiveness and efficiency of brake performance system assessment and thereby reduce the risk of crashes attributable to poor brake performance. These studies provide new information directly comparing the performance of BPM systems in controlled and operational settings. Both study results are limited to the particular systems and applications tested. Study data are available from the FMCSA.

Paper Number 09-0469-O

How To Use Mirrors

Walter Niewoehner
DEKRA Automobil GmbH,, Germany

Abstract
Blind spots of trucks are a very often discussed problem. The usual way to reduce blind spots is to use a mirror. The new mirror regulation 2003/97/EC is improving the visible areas around a truck. The new trucks in Europe are equipped with mirrors which have to fulfil the new mirror regulation. This is the current technical situation. But how do the driver use these mirrors? What do they know about the new mirror systems? Do the driver know how to adjust the mirrors to provide the best view? This paper will provide an overview about the mirror-related knowledge of German truck drivers and, subject to the type of mirror system mounted, how they are adjusted and used. That is followed by the presentation of a solution to an old problem: so far there is no system which shows the driver of a truck whether his mirrors are adjusted in the right way or not. An idea coming from the Netherlands was to use markings painted on the ground to help the truck drivers to adjust their mirrors. This idea was improved by Daimler, MAN and DEKRA and is now offered e.g. to fleet operators to help their drivers. Furthermore the remaining part is about how drivers use there mirrors on the road in different traffic situations.

Paper Number: 09-0181-O

New Requirements To The Emergency Exits Of Buses

Dr. MATOLCSY, Mátyás
Scientific Society of Mechanical Engineers, Hungary

Abstract
Based on certain assumptions, the requirements of emergency exits on buses and coaches are specified in ECE Regulation No.107. Different accident situations, real accidents proved that some of the original assumptions are not valid, so it is necessary to reformulate them. Accident

statistics – containing some hundreds bus accidents – and in depth accident analysis were studied, concentrating on the evacuation of buses and the rescue possibilities of the bus occupants. Certain results and conclusions of evacuation tests are also considered which show the capabilities and limitations of different groups of passengers (men-women, young or elderly people, etc.) when evacuating the bus through different kind of emergency exits. The new assumptions to specify the required number and location of emergency exits of buses are based on the following perception: the United Statesbility of the individual emergency exits are different in different bus categories
(e.g. low floor city bus, high-decker tourist coach, etc.) or even in one category (lower or upper level of a double-decker bus) and also in different accident situations (e.g. frontal collision, rollover, fire, etc.) The next step is to specify the "United Statesbility" in technical, measurable terms. The paper proposes four aspects, shortly: to open the exit, to creep through the exit, to step/jump down from the bus and the possibility of the continuous use of the exit. Some possible measures are proposed to these aspects. On the basis of these aspects, all the emergency exits may be qualified (good, acceptable, poor, not United Statesble) in every bus categories and every accident situation. Finally the required number of emergency exits (how many good, acceptable exit) could be specified which shall be provided for the occupants in every essential accident situation.

Paper Number 09-0427-O

Injury Mechanisms To Mass Transit Bus Passengers During Frontal, Side And Rear Impact Crash Scenarios

Gerardo Olivares, Vikas Yadav
NIAR, Wichita State University, United States

Abstract:
According to the Traffic Safety Facts reports from 19992003, an average of 40 fatalities and 18,430 injuries of bus occupants occurred per year. The objectives of this research are to characterize the kinematics and injury mechanisms of bus passengers during typical frontal, side and rear impact conditions. Accident data from the traffic Safety Fact Reports, Buses Involved in Fatal Accidents Report and Transit Agency data were review to define typical crash scenarios. A detailed finite element model of a low floor transit bus was used to calculate the crash pulses at the passenger compartment for typical frontal, side and rear impact conditions. A series of sled tests with 5th, 50th and 95th percentile occupants were conducted at NIAR's Crash Dynamics Laboratory in order to study the occupant kinematics and to identify injury mechanisms to bus passengers.
The results of this study show that the most common injury mechanisms to bus passengers are head (HIC) and neck injuries (neck extension, flexion and compression). These injuries are due to body-body contact between unrestrained passengers and/or body-to-seat structure contacts.

Paper number 09-0197-O

Analysis Of Coaches Rows Seats Distance Influence On The Passengers Comfort And Safety

Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Luis Martínez, Teresa Vicente, Antonio García, Enrique Alcalá, Francisco Aparicio
University Research for Automobile Research, Polytechnic University of Madrid (UPM – INSIA),Spain

Abstract:.
Rows seats distance is a key parameter for the comfort on coaches. This distance it is also important for the passenger safety and also for example to extend the use of rearward facing CRS in a safer way. This study analyses what could be the minimum distance (based on comfort from volunteer) and how this comfort distance is affecting the passengers level of protection in R80 frontal impact with respect the minimum distance requested in current Regulations R36/R107. Volunteer testing have been performed to obtain the comfort sitting positions for coach seats geometry. Also CAE software has been used to determine minimum row seats comfort distance for a wider sample of seats geometry. In later phase, R80 sleds tests with two and four Hybrid-III dummies and with two types of seats (2-point and 3-point safety belts) have been performed, to asses the level of protection of the passengers in frontal impact at the current R36/R107 row seats distance and with the proposed one.
This study present a recommendation for a minimum row seat distance to guarantee passengers comfort and how this distance is affecting the passengers safety in frontal impact with the injury assessment criteria of both R80 and R94 for the Hybrid-III dummy. With 3-point safety belts seats, the increment on the row seat distance is beneficial for the passengers safety, except when they are unbelted and if the design of the seat is maintained. With 2-point safety belts seats, the level of protection is similar for both distances. The R94 neck injury criteria and tibia displacement are over exceed even with the lower R80 impact speed (55 kph vs 30 kph). This study shows the status of coaches frontal impact protection levels after the 2003/20/CE Directive has been made compulsory the use of the safety belts in coaches even in the city and road travels.

Paper Number 09-0194-O

Improving Motorcyclists' Safety In Spain By Enhanced Crash Test Procedures And Implementation Guidelines

Juan García, David García, Aquilino Molinero, José Miguel Perandones
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José Antonio Fernández, Carlos Martín
Junta de Castilla y León
Alberto Mansilla
Universidad de Valladolid, Spain

Abstract:
Motorcyclist fatalities are a major road safety problem on Spanish roads. In 2006, 642 motorcyclists or cyclists fatalities occurred, which mean 21% of all road fatalities. More than half of them were run-offs. To address this safety issue, roadsides are equipped with so-called "Motorcyclist Protection Devices" (MPD). In 2005, the Spanish Standard UNE 135900 for the

assessment of MPD was published, and Spanish National and Regional Road Administrations have been active in this field since then.
This paper describes research work aimed at improving motorcyclists' safety from a global approach, by two main activities:
-Upgrading the crash test procedure set by Standard UNE 135900, by implementing a new thorax injury criterion.
-Developing a methodology to recommend and warrant the installation of MPD on specific road stretches.
The implementation of a thorax injury criterion took into account the kinematics and injury caUnited Statestion process in the event of an impact of a motorcyclist sliding against a barrier. From the analysis of the response of bones, inner organs and vascular system it was concluded that loads measured on the vertebral column with a Hybrid III dummy are suitable to assess relevant thorax injuries. An injury criterion based on maximum vertical force measured on thorax was defined and implemented into the upgraded 135900 Standard.
The recommendations for the installation of MPD were based on analysing road sections and identifying bends with a higher risk of motorcyclist run-off collision, in order to install such devices with optimised cost effectiveness. The applied methodology comprised road inspections and epidemiological analyses in order to detect relevant risk factors.
As a result, a framework is provided that sets technical bases for the development and implementation of better motorcyclist protection devices, by assessing their performance through an enhanced standard, and by establishing scientifically–based criteria for their deployment.

Paper Number: 09-0448-O

Status Of NHTSA's Motorcoach Safety Plan

Aloke Prasad, David Sutula, Roger Saul, John Hinch, Charles Hott, Lawrence Valvo, Stephen Beretzky
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Michael L. Sword
Transportation Research Center, Inc., United States

Abstract:
The United States Department of Transportation, National Highway Traffic Safety Administration (NHTSA), has been actively researching ways to improve bus safety for several years. In 2007, NHTSA completed a broad review of motorcoach safety issues in the United States and developed an approach that would be pursued to most expediently address those issues. This paper discusses the priority areas that are being investigated for improvements, presents the approach that is being taken in each priority area, and summarizes the status and research results obtained thus far.
While there are a number of agency programs that encompass motorcoaches, the agency has decided to pursue these efforts as priorities: passenger ejection, roof strength, fire safety, and

emergency evacuation.
For passenger ejection, incorporation of seat belts has been pursued as the most expedient way to mitigate ejection. A full scale frontal 30 mph barrier crash test was conducted to measure the occupant responses for both belted and unbelted conditions, and sled testing under a variety of configurations was completed to assess seat anchorage and seat belt load experienced under these conditions.
Regarding roof strength, tests on four motorcoaches were conducted to assess and compare European and U.S. requirements for roof strength in buses. Survival space and emergency exit operation were studied for both test conditions.
To address emergency evacuation on motorcoaches, studies and human evacuation simulations are being conducted. Various emergency exit scenarios including windows, rear stairs/door, existing wheelchair exit doors, airplane style portals, and roof exits are being evaluated. Minimum strength requirements for opening emergency exits based on the age of the occupant are also being examined.
As for fire safety, NHTSA is conducting research to examine how a motorcoach fire spreads from the wheel well to and through the passenger compartment. The flammability of interior and exterior materials will be investigated, as well as detection systems to warn the driver of an external fire along with automatic suppression systems to quell a fire before it spreads.

Paper Number 09-0385-O

Study On Visibility And Discomfort Glare Of Adaptive Front Lighting System (AFS) For Motorcycles

Masanori Motoki, Hiroshi Hashimoto, Tamotsu Hirao
Japan Automobile Research Institute, Japan

Abstract:
When a motorcycle is driven on a curved road, the motorcycle headlamp inclines horizontally as the motorcycle body banks, and the area illuminated by the headlamp becomes limited. Therefore, minimizing the horizontal inclination of the headlamp would improve the visibility. This study was conducted to clarify the effects of a system to adjust the horizontal inclination of the motorcycle headlamp (hereafter, “motorcycle AFS”) on visibility for the rider, and to examine the side-effects of the motorcycle AFS (e.g., discomfort glare for oncoming drivers). The study included the following two parts:

(1) A simulation survey and an actual driving survey to test the visibility demonstrated that a motorcycle AFS enhances visibility for the rider while the motorcycle is being driven on curved road. When the horizontal inclination of the headlamp is adjusted by the same or greater amount than the bank angle of the motorcycle body, the visibility evaluation scores are equal to or above the just acceptable level. However, when the adjustment amount is less than the bank angle, the visibility evaluation scores are below the just acceptable level.

(2) A simulation survey and an actual driving survey to evaluate the discomfort glare showed that when the horizontal inclination of the headlamp is adjusted by the same or smaller amount than the bank angle, the glare evaluation scores are equal to or above the just acceptable level. However, when the adjustment amount is more than the bank angle, the glare evaluation scores are below the just acceptable level.

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Based on the results obtained in this study, the following technical requirement is proposed for the motorcycle AFS: "A horizontal inclination adjustment system (HIAS) may be installed. However, the adjustment amount of horizontal inclination shall not exceed the vehicle's bank angle."

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Paper Number 09-0254-O

Effectiveness Evaluation Of Antilock Brake Systems (ABS) For Motorcycles In Real-World Accident Scenarios

Dr. Georg Roll, Oliver Hoffmann
Systems and Technology, Continental AG, Chassis & Safety, Germany
Jens König
DEKRA Automobil GmbH, Germany

Abstract:
Although motorcycle ABS is meanwhile well established on the public market, detailed investigations about the relationship between crash scenarios and the effectiveness of motorcycle-ABS are rare. Within the EC-funded SIM Project (Safety In Motion) a detailed analysis of different accident scenarios with PTWs (Powered Two Wheelers) has been performed, using the DEKRA PTW-database. The basis of this data pool is the accumulation of written expert opinions containing the accident analyses that are drawn up by skilled forensic experts throughout Germany. From this database containing 350 real-world accidents, 51 cases have been selected by imposing a reaction demand and a following braking of the motorcycle rider in order to evaluate the benefit of advanced brake control systems. The following parameters have been extracted for the evaluation:

- -Collision speed and initial speed
- -Distance of falling location to collision point
- -Braking distance
- -Median braking deceleration
- -Starting point of breaking
- -Reaction point/demand
- -Kind of reaction
- -Road surface
- -Weather

With this information several real accident scenarios without ABS were analysed under the condition that an ABS system would have been installed on the motorbike. With such an approach the difference in the accident consequences with and without ABS can be observed. In addition a variation in the ABS control has been accomplished by considering different brake control systems developed by CONTI, like partial and full integral brake systems as well as systems with advanced driver-assistance functions (ADAS).
As a result, a tremendous reduction in the accident consequences can be shown, for example up to 50% of the selected accidents could have been avoided by a simple 2 channel ABS.

Paper Number 09-0260-O

Dynamic Analysis Of Side-By-Side Utility And Recreational Vehicles

Alex Roberts
Testing, The Engineering Institute, United States

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Abstract:
Over the past several years, there has been seen an increasing popularity of side-by-side utility and recreational vehicles (also referred to as UTVs and ROVs), which resemble road-going passenger vehicles more so than typical ATVs due to bench/bucket seats, safety belts, steering wheels, etc. Some of these perceived safety advances over standard ATVs are reasons for their increased popularity. Therefore, it is important to begin using basic passenger car vehicle dynamics knowledge and testing techniques to enhance the safety of these vehicles by making them perform more like road-going vehicles in terms of both directional stability and rollover resistance.
Recent research by The Engineering Institute has resulted in a quantification of the performance aspects of a typical side-by-side using standard automobile tests such as SAE J266, ISO Avoidance Maneuvers, J-turns, and a slalom course. Simple vehicle modifications were also performed that dramatically improved the performance of the vehicle through the same maneuvers.
This paper will discuss the results of both the testing on the standard and modified vehicle. Data from the testing will be presented, and the vehicle modifications will be illustrated. Conclusions will be made detailing the effectiveness of using basic passenger car vehicle dynamics principles at drastically improving the safety of side-by-sides.

Written Papers

Technical Session
Data Acquisition and Analysis for Future Safety Enhancement

Paper Number 09-0031-W

VIIS – Vehicle Infrastructure Interaction Simulation On "Real" Roads

DI Peter Saleh, DI Rainer Stütz, Mag.,Stefan Deix, DI (FH), Stephan Kunz, Priv.-Doz. DI Dr. Peter Maurer
Arsenal research – Österreichisches Forschungsund Prüfzentrum Arsenal Ges.m.b.H,. Austria

Abstract:
The project VIIS (Vehicle Infrastructure Interaction Simulation), an actual research project which was started in January 2008 has the aim to build up on the MARVin (Model for Assessing Risks of Road Infrastructure; Paper of the 20th ESV) outcomes. The idea is to develop a combined simulation system, including all kinds of RoadSTAR data (Road Surface Tester of arsenal research; road condition and trace geometry) to verify crash caUnited Statesl combinations. The MARVin software tool has been upgraded with traffic density data to get some more comparable and significant results. The crash caUnited Statestions regarding to poor surface characteristics or in-harmonic road geometry can be identified with a higher probability.
The main work is to integrate all relevant RoadSTAR parameters in a simulation software tool. In a beginning procedure a integration in the software PC Crash shows some positive results. The challenge will be to bring the skid resistance values as DXF data in a high density on the virtual route.
Virtual road sections can be designed with real measured data. Crash reconstructions and crash caUnited Statesl combinations (MARVin) are feasible. All kinds of vehicle dynamic data, which can be also logged in the CAN bus system, can be simulated and recalculated. The vehicle infrastructure interaction (road/tyre, suspension/tyre) in a crash situation leads to possible accident compensation measures like new in-vehicle sensors, innovative active safety systems, real time accident risk assessment, interactive road condition maps, etc..
The key point for the future of traffic safety issues are to verify MARVin results with vehicle-infrastructure simulations and to derive preventative measures either on the construction side or in the in-vehicle safety applications.
Visions are to combine theoretical accidentology with practical preventative solutions. Policy, vehicle manufacturer, road operators and map providers can have a benefit resulting from this research.

Paper Number 09–0048-W

Fusion Of In-Vehicle Sensor Data To Develop Intelligent Driver Training System (IDTS)

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Technical Session
Data Acquisition and Analysis for Future Safety Enhancement

Technology, Australia

Abstract:
The over represented number of novice drivers involved in crashes is alarming. Driver training is one of the interventions aimed at mitigating the number of crashes that involve young drivers. To our knowledge, Advanced Driver Assistance Systems (ADAS) have never been comprehensively used in designing an intelligent driver training system. Currently, there is a need to develop and evaluate ADAS that could assess driving competencies. The aim is to develop an unsupervised system called Intelligent Driver Training System (IDTS) that analyzes crash risks in a given driving situation. In order to design a comprehensive IDTS, data is collected from the Driver, Vehicle and Environment (DVE), synchronized and analyzed. The first implementation phase of this intelligent driver training system deals with synchronizing multiple variables acquired from DVE. RT Maps is used to collect and synchronize data like GPS, vehicle dynamics and driver head movement. After the data synchronization, maneuvers are segmented out as right turn, left turn and overtake. Each maneuver is composed of several individual tasks that are necessary to be performed in a sequential manner. This paper focuses on turn maneuvers. Some of the tasks required in the analysis of 'turn' maneuver are: detect the start and end of the turn, detect the indicator status change, check if the indicator was turned on within a safe distance and check the lane keeping during the turn maneuver. This paper proposes a fusion and analysis of heterogeneous data, mainly involved in driving, to determine the risk factor of particular maneuvers within the drive. It also explains the segmentation and risk analysis of the turn maneuver in a drive.

Paper Number 09-0136-W

Cooperative Sensor Technology For Preventive Vulnerable Road User Protection

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Abstract:
In the proposed cooperative sensor system, pedestrians carry a reactive transceiver which is interrogated by a localization and tracking unit in the car. The prototype system applies Round-Trip Time-of-Flight (RTOF) techniques for the determination of the distance between the transponder and the demonstrator vehicle. A smart antenna array integrated into the car is used to determine the Direction-of-Arrival (DoA) of the transponder's response signal. Knowing the distance and azimuth angle relative to the car, the pedestrian's position and movement are calculated. These data are used as input for a highly reliable collision warning and collision mitigation system. The sensor system is capable of addressing a huge number of communication partners within each measurement cycle. Additionally, secure burst identification is ensured for a robust localization and the suppression of unwanted co-channel interference. This is achieved by using pseudo random coded signals with a Time Division Multiple Access

(TDMA) method. The distance accuracy was improved by introducing a new mirror technique in combination with an interpolation algorithm. The prototype localization system set up at 2.4 GHz covers a range up to 200 m in free field condition. With the current system a distance resolution with centimeter accuracy and an angular measurement accuracy of about 1 degree have been achieved. Based on this low-cost transponder-based localization system, a preventive vulnerable road user (VRU) protection system has been designed and integrated in a test vehicle. The system is capable to provide a warning to the driver if a crash is likely and to autonomously brake the vehicle if the crash is unavoidable.

Paper Number 09-0163-W

Using The Objective Rating Method (ORM) As A Quality Assessment Tool For Physical Tests, Test Methods, And Mathematical Models

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Abstract
There is a daily need to assess the quality of our work. On the crash track, the tests should be repeatable, the chosen test method should fulfil the test purpose and every result should have an explanation. The tests performed may also be used to validate mathematical models, the accuracy of which must then be assessed, or, to show whether a new design or method influences the performance or not. Regardless of which, there is a need of a quality assessment tool. By applying the Objective Rating Method on performed rear-end sled tests, Autoliv has previously shown that the BioRID II dummy allows for both repeatable and reproducible testing. Here, the ORM has been evaluated on frontal, side impact and component tests and the corresponding models.
For frontal impacts, test repeatability has been assessed, and correlation between physical tests and mathematical models are shown. For side impacts, the test repeatability, test method predictability and mathematical model predictability have been assessed. The repeatability of frontal sled tests is comparable with that presented for rear-end sled tests, while the side impact sled test repeatability is generally somewhat lower.
Although the ORM has to be used with care and knowledge, it is a useful tool, especially for assessments regarding test repeatability and reproducibility. The ORM allows for agreement, in advance, on a quality level for tests and mathematical models. Beneficial is that the ORM not only compares peak values but also curve shapes. Furthermore, the ORM compares two tests; many methods require several tests and that is normally not available in daily work.

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Paper Number 09-0200-W

Driver Behavior Modeling Using Hybrid Dynamic Systems For 'Driver-Aware' Active Vehicle Safety

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Abstract
Modern safety systems are transforming vehicles from human-controlled passive devices into human-centric intelligent/ active systems. There is a wide range of systems from fully autonomous vehicles to human-augmented control devices which have emerged in this field. In current trends, co-operative active systems have the driver in the decision and control processes are favored for their 'human-centric' approach. However, these systems pose a challenge in the design process since obtaining reliable human behavior models are difficult due to the complex nature of driving task in a dynamic traffic environment. From a control theory perspective, driving can be seen as a combination of continuous control segments combined with a discrete decision process. In this study, we will model driver behavior utilizing Hybrid Dynamic Systems (HDS) combining stochastic modeling tools (such as Hidden Markov Models) with control theoretic models. A subset of CAN-Bus and video channels from a demographically balanced UTDrive Corpus containing video (2 channels: driver and road scene), audio, and CAN-Bus signals of realistic driving sessions for 77 drivers are used to verify HDS models of lateral and longitudinal control behaviour. The model is used to suggest 'driver-aware' active safety system capable of assisting the driver in several lateral control tasks; lane-keeping, curve-negotiation and lane changing

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Paper Number 09-0326-W

Yaw Rate Error – A Dynamic Measure Of Lane Keeping Control Performance For The Retrospective Analysis Of Naturalistic Driving Data

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Abstract:
The aim of this work is to define and evaluate a "yaw rate error" (YRE) derived from naturalistic driving data to quantify driver steering performance during lane keeping. This measure of lane keeping performance is based on the predicted kinematic control error at any instance. Scope is limited to the demonstration that such a quantity exists, that can be computed from naturalistic driving data, and that it correlates with instantaneous control performance in real-world driving. The YRE is defined as a measure of conflict: the difference between current vehicle yaw rate and kinematic values required to be consistent with forward lane boundary crossing. A second, well-known measure is computed for

comparison: the predicted time to lane crossing (TTLC). All data is obtained from naturalistic driving databases containing detailed information (over 200 signals at 10 Hz.) on driver input and vehicle response as well as aspects of the highway and traffic environment. As a continuously updated measure of the control correction required by an alert driver, it is expected that the YRE will be more informative of driving situations than the simpler kinematic measure TTLC. This latter measure is only loosely related to the closed loop control of vehicle motion. For example a very small TTLC can represent either a critical case where the vehicle is about to depart the lane and requires a large correction, or it could be a case where the vehicle is close to the lane boundary but with small lateral velocity requiring only a small correction. The YRE represents the severity of the possible lane departure in a natural way, accounting for current position, path direction, and path curvature. While no in-depth statistical analysis is conducted for YRE, it is proposed as a new tool for post-hoc analysis of driver steering performance during lane keeping.

Paper Number 09-0332-W

Methods And Procedures For Testing The E-Call In-Vehicle Unit For The Purpose Of Its Performance Assessment And Certification

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Abstract:
The main idea behind the pan-European eCall project is to automate the emergency call that is simultaneously extended by a message containing information such as current position and prior-tocrash speed, type of vehicle, VIN, VRN, number of passengers travelling, etc. The in-vehicle unit consists of measurement, communication, positioning and user-interface sub-systems, and all those sub-systems need to pass functional and performance type examinations before the device can be granted formal approval from the notified laboratory. The usual way of testing the module will be during the type approval of the car, as performance of the unit is strongly correlated to the dynamical parameters of the vehicle body and fitting procedures. Technology of today makes it relatively easy and straightforward to measure linear and angular accelerations of the vehicle chassis to estimate its full state in the 6DOF space, however, the number of sensors required and resulting cost is mostly prohibitive, thus in practical solutions the crash detection is to be implemented based on signals acquired from a limited number of available sensors, preferably already present in the existing set-up, using also additional sources of data, such as longitudinal velocity from the speed sensor.
The purpose of the project is to design a testing methodology and set-up a testing bench for the

type certification of the in-vehicle e-Call system units for the accredited laboratory. The test stand should allow the production of precise and repeated predefined testing conditions to excite the device-under-test sensors and to relate their logged data and results to those of reference set of sensors built-in to the test stand. Another question we address during the study is the feasibility of data gathered in the in-vehicle e-Call unit for the purpose of reconstructing the crash.

Paper Number 09-0346-W

A Comparison Of Computer Modeling To Actual Data And Video Of A Staged Rollover Collision

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Abstract:
Vehicle accidents in which the automobile "rolls over" or overturns are among the most difficult accidents to reconstruct. Vehicles typically overturn about their longitudinal axis and in highway speed rollovers can overturn multiple complete revolutions. The accident reconstruction specialist is left to piece together the incident from physical evidence produced both on the vehicle and at the accident site. A number of works have been published by various authors detailing the methods for calculating many aspects of the accident. Using these methods the reconstruction professional is obliged to illustrate and present the accident using two-dimensional or three-dimensional drawings to illustrate the accident. One can also use such a diagram to produce an animation of the accident. These animations are based on one's own conceptualization of the accident as physical evidence reveals, but they are not the result of the extensive time step calculations of vehicle dynamics that can be done with computer reconstruction software.
As the computer has become more powerful and faster, physics based modeling programs have been developed to aid the reconstruction professional with the analysis of automobile accidents. For the most part, accident reconstruction software packages do not contain detailed component/suspension modeling capability. However, for the purposes of accident reconstruction, the models in these software packages are more than sufficient to model an accident scenario such as a vehicle tumbling or rolling over.
In this paper, a reconstruction of a staged rollover accident involving an SUV type vehicle will be presented. The subject rollover is a staged un-tripped rollover. The test vehicle overturns because of frictional forces at the tires imparted by steering inputs. This rollover is modeled using PC Crash™. The test site was well documented after the event and pertinent physical data was recorded. Damage produced on the vehicle as a result of the rollover is also well documented. Numerous video cameras were used to record the rollover from a variety of vantage points. All of this information is used in conjunction with the software to demonstrate how properly used software can effectively model a rollover accident. If rollover accidents can

be accurately modeled, then the data may be used in developing vehicle safety and occupant protection systems.

Paper Number: 09-0415-W

Computerized Crash Reconstruction Of Real World Crashes Using Optimization Methodology

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Abstract:
Computerized crash reconstruction of real world crashes involves dealing with a lot of unknown parameters and as such the reconstruction problem cannot be solved deterministically as was shown using a parametric methodology presented in our previous ESV paper titled "Computational Analysis of Real World Crashes: A Basis for Accident Reconstruction Methodology." This paper introduces a modified version of the parametric methodology, which involves using an optimization scheme to derive an optimal solution for the reconstruction problem in a given range of unknown parameters. Real world crashes were selected from the CIREN database and were solved using the proposed methodology. Human-Vehicle-Environment (HVE) software was used to generate the crash pulse where EDR data were missing. The problem was set up in MADYMO. During the set up, the unknown parameters were identified. ModeFRONTIER software was used for optimization. The identified unknown parameters were treated as design variables. The objective function and the constraints were defined such that they minimize the differences in injuries and occupant-vehicle contacts between the real world data and the model prediction. Since the objective function has a great effect on the final solution, a normalized form of the objective function, weighted based on the AIS level of the injuries sustained by the occupant, was formed in this study. A genetic algorithm with Sobol DOE (Design of Experiments) was used for optimization. Results of the simulations showed that the optimal solution correctly predicted both the occupant-vehicle contacts and the injuries sustained by the occupant. By viewing the occupant motion inside the vehicle during the crash, better occupant protection systems can be devised. Correlation studies were also carried out to find the critical parameters affecting the solution. In addition, a best case scenario study was carried out to find, using optimization, the design changes that could help mitigate all or some of the injuries sustained by the occupant.

Paper Number 09-0424-W

Crush Vs Energy Relationship For Yugo GV – Case Study

Krsto Lipovac, Milan Vujanic

Technical Session
Data Acquisition and Analysis for Future Safety Enhancement

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Abstract:
Due to extremely different vehicle structural performance it is required to individually analyze vehicle stiffness in any situation where accurate results of calculating crash speed are needed. From the beginnings of vehicle stiffness modeling, by Emori, Campbell or any of there successors, methods of establishing equations are constantly improved. Nowadays, it is well known that normalized crush energy (known as EAF-Energy of Approach Factor) vs deformation can be successfully approximated with linear relationship using results from NHTSA 30 m/h frontal crash test speed. For higher speeds, bi-linear appeared to be accurate enough in most cases. But, there are certain cases where different relationship could give better results. Some researchers showed that nonlinear relationships could be also successfully used. In this work, all known attempt previous.researchers where exercised on a YUGO GV vehicle. For this vehicle there are three NHTSA full frontal tests available. Using those results, it was concluded that, although bi-linear relationship could be successfully used, best performance was achieved by combined approximation. Linear up to speed of 30 m/h and quadratic above that speed. This approximation gives best results in upper register of speeds, thus it is useful for very deep crash deformations. Using computer for analysis eliminate complicated calculations, so establishing such relationships is no more hard job. It is important to notice that this kind of approximation can't be applied in situation where only one crash test point is known. So, field of application is very limited.

Written Papers

Technical Session
Developments in Frontal/Side Impact Protection

Paper Number 09-0021-W

Development Of Moving Deformable Barrier Reproducing Struck Car Deformation In Real-World Car-To-Car Side Impact Accidents In Europe And Japan

Taisuke Fujiwara, Kenji Shigeta
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Abstract:
The test procedures described in current European and Japanese side impact regulations and assessments involve striking a moving deformable barrier (MDB) into a stationary test vehicle. However, since many car-to-car side impact accidents in the real world occur when the struck vehicle is also moving, the force direction into the struck vehicle in the configurations described by these regulations and assessments differs from that in those actual accidents. Therefore, to simulate the force into a moving struck vehicle in the current test configuration, i.e., a perpendicular MDB side impact, it is necessary to integrate the stiffness characteristics of the front of the striking vehicle in a side impact accident where both vehicles are moving. Consequently, a crabbed frontal impact test that simulates the force direction into the striking vehicle in a moving car to moving car side impact test was considered as an evaluation method for the frontal stiffness characteristics. This crabbed frontal impact test was confirmed to be capable of measuring the stiffness characteristics of the front of the striking vehicle occurring in a moving car to moving car side impact. In addition, an MDB for simulating crabbed frontal impacts was developed based on the frontal stiffness characteristics obtained from the crabbed frontal impact test. It was confirmed that side impact tests using this MDB were capable of simulating the deformation and door moving velocity of the struck vehicle in a moving car to moving car side impact test. As a result, vehicle safety enhancements based on a side impact test method using this MDB are expected to contribute to the development of appropriate body structures and restraint devices for real-world accidents.

Paper Number 09-0071-W

A Holistic Approach To Pedestrian Protection And Crash Sensing

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Abstract:
Recent legislation has increased the type approval requirements in the domain of pedestrian protection. A non design restrictive solution for the bonnet area is the implementation of pop-up bonnet systems. Obviously, such systems need a sensing element detecting and classifying the impact object in order to make a fire/no-fire decision for the bonnet lifting actuators.
The working principle of IEE's pedestrian protection sensor system not only allows the

detection of pedestrian-type impacts, but also analyses crash event scenarios. Thus the same sensor is not only used for pedestrian protection, but can also contribute to passive safety by delivering information that can be used for enhanced occupant safety. In decision-making for the pop-up bonnet deployment, it is crucial to reliably distinguish between pedestrians and other objects like traffic signs, footballs or small animals, whereas in crash sensing, it is helpful to know as early as possible whether the collision object is a tree or a vehicle.
The pressure sensitive sensor is integrated into the vehicle front-end and detects parameters like T0 (first contact), impact location, width of impacting object and impact dynamics. These data allow a more precise tuning of the restraint systems to specific crash events, the United Statesge of less aggressive restraint systems due to the early T0 signal, as well as the replacement of existing sensors (upfront, pole catchers, redundancy).
The sensors ability to deliver robust data in frontal crashes has been demonstrated in tests reflecting compliance, consumer and insurance testing requirements.
In order to provide even more information about crash situations and to offer optimised and cost-effective solutions for other applications, the goal is to develop a family of general impact sensors also covering the detection of rear-end collisions and side impacts.

Paper No. 09-0100-W

Study On Improving Occupant Injury Performance For FMVSS 214 Side Pole Impact

Young Woong Kim, Byung Ryul Ham, In Ho Choi, Han Il Bae
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Abstract:
NHTSA (National Highway Traffic Safety Administration) has published an update to the FMVSS214 regulation which includes the Pole Impact test configuration using the ES-2re and SID-IIs dummy. This updated standard adds a new side pole test requirement in addition to modifying the test procedure used to perform dynamic side impact testing. This paper shows a new technique to improve the occupant injury performance during the Pole Impact test.

Paper Number 09-0109-W

An Evaluation Of PDB Test Results For Partner Protection And Self Protection

Kaoru Tatsu, Akira Yamaguchi, Atsushi Hitotsumatsu, Tomosaburo Okabe
Nissan Motor Co., LTD., Japan

Abstract:
The introduction of various vehicle safety standards and new car assessment programs in addition to automobile manufacturers' efforts to improve vehicle safety performance have led to significant improvements in vehicle safety performance over the past several years. Improving frontal impact compatibility is recognized as one approach to further enhancing vehicle safety performance. Various methods of improving frontal impact compatibility have been proposed and discussed.
In 1996, European Enhanced Vehicle-safety Committee Working Group 15 on Vehicle

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Compatibility was established to explore methods for assessing vehicle compatibility and to develop procedures for testing it. In their 2007 Final Report, EEVC WG15 proposed a Progressive Deformable Barrier (PDB) test as one candidate for testing vehicle compatibility. The PDB test was developed with the aim of assessing and improving partner protection while taking self protection into account as well.
This paper focuses on the PDB test. To assess its performance, several different category vehicles (small car, large car, midsize SUV, large SUV) were selected for study and PDB test results for them were compared with those obtained with the current ECE R94 offset deformable barrier (ODB) test and the vehicle-tovehicle impact test. This study was simply an attempt to make an evaluation of the PDB test in comparison with other test procedures.

Paper Number 09-0110-W

A Proposal For An Improved Method Of Evaluating Vehicle Compatibility In Full-Frontal Rigid Barrier Tests

Akira Yamaguchi, Atsushi Hitotsumatsu, Tomosaburo Okabe
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Abstract:
In frontal collisions, injury risk can be reduced if the front body structure is able to absorb a greater amount of energy. In general, however, in front-to-front collisions between different-size vehicles, the smaller, lighter vehicle sustains greater damage than the larger, heavier one. To help improve vehicle compatibility in front-to-front collisions between such vehicles, what is required is better matching of the geometry and stiffness of the front structures of the colliding vehicles.
Several methods of measuring the geometry and stiffness of front structures have previously been reported. Among these are the AHOF400 and Kw400 metrics, which are measured in full-frontal rigid barrier tests using high-resolution barrier load cells. This paper proposes an improved method for evaluating compatibility in full-frontal rigid barrier tests based on a review of the purposes of and issues with the AHOF400 and Kw400 metrics.
The methods proposed in this paper are intended to help provide an improved compatibility assessment compared with the AHOF400 and Kw400 metrics by evaluating the forces on load cells in an area defined as the structural interaction zone. Like AHOF400 and Kw400, the aim of this research is to improve structural engagement and energy sharing in the event of a front-to-front collision.

Paper Number 09-0152-W

Numerical Simulation Of Crash-Test For A Formula SAE Car

Simonetta Boria, Giuseppe Forasassi
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Abstract:
Crash-tests and numerical simulations are vital sources of information for designing car safety elements. The aim of this study is the design of a crash-box for a Formula SAE car and the investigation, through a numerical approach, of its dynamic behaviour in frontal impact

conditions. The impact attenuator is obtained by the combination of honeycomb sandwich panels and aluminium sheets. Firstly experimental tests and numerical analysis on honeycomb structures were carried out in order to better understand their behaviour and model them properly. Afterwards a global 3D model was built and discretized with finite element method (FEM) in the Ansys code, while the simulation of the crash itself was done by means of the Ls-Dyna code. The crash-box has been optimized regarding several parameters so that the performances required by Formula SAE rules are achieved with minimal structural weight. The obtained results show that the impact attenuator by itself is able to absorb the total kinetic energy with dynamic buckling and plastic deformation of its structure with an average deceleration limited under a 20g value.

Paper No. 09-0173-W

Performance Analysis Methodology Based On Crash Pulse Severity And Vehicle Occupant Packaging For Full Frontal Crash Event

Bo Pil Seo, Sung Jun Han, Won Chul Kim, Si Yeol Kim
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Abstract:
Under full frontal crash events, major factors affecting occupant injury are crash pulse severity, restraint system, and vehicle occupant packaging space. The crash pulse severity represents the total performance of collision energy absorbed by vehicle structure during the crash event. The pulse severity also has a close relationship with the energy absorbed by restraint system out of the occupant's total kinetic energy induced by crash event. The capacity of energy absorption by restraint system is affected by the vehicle occupant packaging space. Thus, it is important to perform both restraint system and packaging space optimization simultaneously to manage the energy transfer under given severity of crash pulse. In this study, severity function is defined to represent the regression curve of resultant energy absorbed by occupant, based on G-D curve and occupant packaging space. To build the regression curve, US NCAP top rated vehicles were analyzed and the relation between crash pulse severity and severity function is derived for various vehicle grades. Based on the result, target requirements of crash pulse severity and severity function are determined to satisfy occupant safety performance goals. This methodology is very useful to evaluate the crashworthiness performance of vehicle body design concept efficiently at early development stage.

Paper Number 09-0174-W

Development Of Test Methods For Evaluating Curtain Airbag Deployment Force

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Hyun-Yong Jeong
Sogang University, Korea
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Hyundai Mobis, Korea

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Abstract
It is well known that a CAB (Curtain Airbag) is one of the most effective restraint systems for protecting the occupant head from a side impact crash or preventing the occupant from ejection during a rollover accident. One of the most fundamental requirements for a CAB is to ensure a robust deployment. Specifically, a CAB should be deployed and positioned well in time without being trapped by any interior parts. Up to now, the deployment performance has been evaluated by measuring the fully-deployed time, which has limitation in that it is difficult to clearly discriminate performance differences resulting from design parameter changes. The main purpose of this study is to develop a new methodology for evaluating the CAB deployment performance quantitatively and defining corresponding metrics representative of the deployment performance. For this, two test methods focusing on either the local or the global characteristics were developed in the present investigation. The first was designed to directly measure the deployment force exerted on the specific area by measuring the tension force acting on a webbing material using the load cell. The second was devised to show the overall profile of the deployment force and to measure the time history of total force by calculating the sum of inertial and elastic forces applied to a series of spring-bar impact systems. Afterward, several tests were carried out by each method in order to evaluate their repeatability and reproducibility. In addition, the tests were performed for several different CAB designs to evaluate discrimination capability of each test method. From this study, it was found out that the proposed test methods and corresponding metrics can be effectively used for evaluating the deployment performance of CAB's. It is also expected that the methodology can be applied to optimize design parameters of CAB's for the robust deployment performance.

Paper Number 09-0175-W

Environmental Perception For Future Integrated Safety Systems

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Silvia Pietzsch, Stefan Hahn
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Abstract:
World wide social developments towards Mega-Cities, define future tasks for automotive safety systems. Advanced driver Assistance systems in combination with new preventive safety systems offer great potential for mitigating accidents, reducing accident severity and increasing occupant protection. Traffic in Mega-Cities is characterised by a much higher degree in complexity and dramatically reduced observation time. Thus, automotive safety systems have to face much faster decision requirements compared to present day cruse control systems. Hence, the capability to assess and perceive the actual driving situation in complex traffic situations is the key enabler for future vehicle comfort- and safety systems. The symbiotic exploitation of the electromagnetic spectrum by means of Radar- and optical sensors like Scanner and Vision sensors allows the comprehensive and precise detection even at adverse conditions. The article describes possible approaches.

Technical Session
Developments in Frontal/Side Impact Protection

Paper Number: 09-0188-W

Analysis Of Injury Trends In Frontal University Of Michigan Ciren Cases In The Context Of Crash Tests

Bridget O'Brien-Mitchell, Kacy Bailey, Daniel Faust, Jack Jensen, Julie Kleinert, Christine Wodzinski, Carla Kohoyda-Inglis, Stewart Wang
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Abstract:
Four-hundred forty two U-M CIREN (University of Michigan Crash Injury Research and Engineering Network) cases have previously been compared to crash tests used in the automotive industry. The comparison demonstrated that the majority of cases were similar in crash configuration and extent to industry crash tests, while smaller proportions either had a greater extent of crash deformation or had different crash configurations than those commonly produced in crash tests. Of the 442 cases, 290 frontal cases were analyzed in greater detail to understand trends in injury caUnited Statestion while considering physical characteristics of occupants (gender, age, body mass index.) Those trends were then evaluated in the context of biomechanics of crash test tools such as Anthropomorphic Test Devices [ATDs] and injury risk curves. Several trends were identified and presented.

Paper Number 09-0211-W

Fireworthiness: A Final Report On The Technology Base

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Abstract:
The findings provide a technology base for fireworthiness including the following: fire statistics on crash modes; the behavior of plastic gasoline tanks when subjected to fire and impact tests; finite element analysis of fuel tanks subjected to crash conditions; assessments of automotive fuel components that relate to fire safety; underhood temperatures under driving conditions; flammability of underhood liners; ignition and flammability properties of plastics and underhood fluids; an analysis and synthesis of 22 vehicle burns; fire suppression needs and a laboratory design and test; and examination of fire safety aspects of future vehicle technologies such as 42-volt electrical systems and hydrogen fueled vehicles.
These research results in conjunction with the GM/DoT Fire Research Project have been analyzed and recommendations for fire safety improvements have been proposed. The recommendations include vehicle level fire tests to increases survivability time for crashed vehicles subjected to exterior fires, particularly those that originate under the hood.

Paper Number 09-0218-W

In-Depth Field Investigations Of Belt-Restrained Children In Farside Crashes

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Technical Session
Developments in Frontal/Side Impact Protection

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The University of Pennsylvania School of Medicine, United States

Abstract:
Recent attention has focused on adults in farside crashes but little attention has been given to children in farside crashes. Thus, we sought to elucidate Injury CaUnited Statestion Scenarios (ICS's) in children in center and farside seat positions. Crash investigation cases were drawn from the Partners for Child Passenger Safety Crash Investigation database, and the Crash Injury Research and Engineering Network database. Included in the study were children aged 4 to 15 years, involved in a side impact crash, seated on the center or farside in the rear rows, restrained by a seat belt alone (no booster seats or side airbags) and who received an AIS 2+ injury. Excluded cases were those where the only documented AIS 2+ injury was an altered state of consciousness (concussion, amnesia, or brief loss of consciousness). Seventeen cases met the inclusion criteria for this study. The three most frequently injured body regions to receive an AIS 2+ injury were: head, abdomen, and thorax, with thoracic injuries being quite rare. Intracranial injuries included cerebral contusions, subarachnoid hematoma/hemorrhage, edema, and extradural/epidural hematoma. Skull and facial injuries consisted of vault, orbit and maxillary fractures. Eight occupants had torso injuries: lung contusion, clavicle fracture, spleen laceration or rupture, liver laceration or contusion, and laceration or contusion to the digestive tract organs of the lower abdomen. Our results indicate that injury patterns and mechanisms are unique to children, and thus require a mitigation approach different than the adult. Of note, thoracic injuries, which are common in adult farside crashes, are relatively rare in pediatric farside crashes. Farside abdominal injury patterns suggest a lap belt submarining mechanism in children, injuring primarily the intestinal viscera. These findings further support that children require a different approach to injury mitigation than the adult, and have abdominal injuries in farside crashes that may be addressed by injury mitigation solutions for frontal impact.

Paper Number 09-0229-W

Improvement Of Airbag Performance Through Pre-triggering

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Walter Eberle, Julien Richert, Wilfried Bullinger
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Abstract:
In the near future road cars will be able to detect probable collisions before they happen. Then it will be possible to avoid some accidents by specific actions of driver assistance systems. If a crash is unpreventable, the passenger can be prepared for the collision during the residual time. This project determines the potential for a reduction of the injury-risk for car-occupants through an airbag deployment considerably before t0. The goal is to demonstrate possible improvements in order to stimulate the further development of pre-crash-sensors. Through the pre-crash deployment of the airbag various advantages for the occupant can be obtained: If the airbag is fired before t0 it can be designed in a significantly bigger way in comparison to

conventional trigger times because the passenger hasn't moved forward. Thereby a very early coupling of the passenger and resulting low loads are achieved. Another advantage is that the airbag can be inflated more slowly due to much more time available. So the deployment of the airbag can be performed in a gentle way which leads to a less aggressive system that promises improvements especially in out-of-position (OOP) situations. There is still no future perspective for a hundred percent detection rate of pre-crash-sensors, so the airbag-system will additionally be designed for conventional trigger times. It is mandatory that in case of a failure of the pre-crash-sensors the occupant is protected at least as well as in today's series-production vehicles. This analysis investigating the potential of precrash activated airbags is based on multibodysimulations with different dummies and crashscenarios. The results of the simulations are going to be verified by principle tests and full-scale sled tests.
Keywords: Airbag, PreCrash, OOP

Paper Number 09-0230-W

Crash Type Distinction Using Structure-Borne Sound Sensing

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Abstract:
Current crash sensing systems are normally based on acceleration sensing. Therefore, the deceleration pulses affecting the car's body are used to apply the firing thresholds of the restraint systems. A new kind of crash sensing consists of measuring high frequent chassis vibration regarding frequencies up to 20 kHz: crash sensing based on structure-borne sound (SBS). The main benefit of this technology will be to support the common deceleration-based crash detection in crash type distinction during the early crash phase. To be able to use the acquired data in a physically reasonable way, the events causing SBS during crash important to know.
In the proceeding of the study, the events occurring during a crash are interpreted as shock excitations of different impulse lengths that can be divided into hard and soft events. Valuable results from a multitude of component crash tests on a drop tower test stand are transferred to vehicle crashes in serial development. The applicability of crash separation criteria is examined. The crash type distinction of hard/soft crashes based on structural vibration sensing is the main idea to support the differentiation of hard no fire tests and soft must fire tests. The study shows that shock excitation of the vehicle structure is the most important cause of high frequent vibration signals acquired during vehicle crashes.
The article deals with the United Statesge of high frequent structural vibration in the range up to 20 kHz for crash detection. The understanding of the vehicle being a structure under linear elastic shock excitation leads to a physically plausible United Statesge of the signals for crash type distinction.

Paper Number 09-0243-W

Assessment Of Injury Severity Of Nearside Occupants In Pole Impacts To Side Of Passenger Cars In European Traffic Accidents – Analysis Of German And UK In-Depth Data

Technical Session
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Medical University Hanover, Germany
Raimondo Sferco, Roland Schäfer, Volker Eis
Ford Motor Company, Germany
Pete Thomas, Ruth Welsh
Loughborough University, United Kingdom

Abstract:
The national accident statistics demonstrate that the situation of passenger car side impacts is dominated by car to car accidents. Car side to pole impacts are relatively infrequent events. However the importance of car side to pole impacts is significantly increasing with fatal and seriously injured occupants. For the present study the German in-depth database GIDAS (German In-Depth-Accident Study) and the UK database CCIS (Co-operative Crash Injury Study) were used. Two approaches were undertaken to better understand the scenario of car to pole impacts. The first part is a statistical analysis of passenger car side to pole impacts to describe the characteristics and their importance relevant to other types of impact and to get further knowledge about the main factors influencing the accident outcome. The second part contains a case by case review on passenger cars first registered 1998 onwards to further investigate this type of impact including regression analysis to assess the relationship between injury severity and pole impact relevant factors.

Paper number 09-0255-W

Coupled Human Body Side Impact Model to Predict Thoracic Injury

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Yih-Charng Deng
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Abstract:
The goal of this study was to evaluate side impact crash conditions using a detailed human body model and side impact crash model to provide an improved understanding of side impact injury and the primary contributing factors. This study builds on an advanced numerical human body model, including a detailed thorax, which has been validated using available PMHS test data for pendulum and side sled impact tests. Crash conditions were investigated through use of a coupled side impact model, used to reproduce full scale crash tests. The model accounts for several important factors that contribute to occupant response as noted in the literature: the relative velocities between the seat and door, the occupant to door distance, the door shape and compliance. The coupled side impact model was validated using FMVSS 214 and IIHS side impact test data, comparing the thoracic response predicted by the model to that of the ES-2 dummy used in the crash tests. Importantly, the door and seat models were developed based on experimental data in the literature.
The side impact model was used to investigate the effects of door to occupant spacing, door velocity profile, restraint system, and seat foam properties. The current study was limited to the use of velocity profiles in the direction of impact and did not consider rotational effects or motion perpendicular to the impact direction. It was found that injury as predicted using the detailed

human body model and the Viscous Criterion (VC) was controlled by the second velocity peak typically found in door velocity profiles.

Paper No. 09-0257-W

Impact And Injury Patterns In Frontal Crashes Of Vehicles With Good Ratings For Frontal Crash Protection

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Abstract:
Modern vehicle designs tested as part of US consumer information programs achieve high ratings for frontal crash protection. Research is needed to determine how these tests can be upgraded to further improve occupant protection in real-world frontal crashes. The present study is a detailed analysis of real-world cases with serious injuries resulting from frontal crashes of vehicles rated good for frontal crash protection.
Queries of 2000-06 data from the National Automotive Sampling System-Crashworthiness Data System produced 116 occupants meeting selection criteria. These were drivers and right front passengers who sustained serious injuries in frontal crashes despite being coded as belted. Patterns of vehicle impact and occupant injury were categorized and discussed in the context of potential upgrades to current crash tests.
Asymmetric or concentrated loading across the vehicle front often resulted in occupant compartment intrusion and associated injury. However, just as many occupants were in crashes without substantial intrusion and were injured by restraint system forces or impacts with the vehicle interior not prevented by restraints. Crashes producing injury without intrusion involved multiple impacts more than twice as often.
Future test programs promoting structural designs that absorb energy across a wider range of impacts, such as small overlap, could reduce serious injuries in frontal crashes. Further restraint system improvements may require technologies that adapt to occupant and crash circumstances. It is unclear what types of full-scale crash testing would encourage these improvements.

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Paper Number 09-0272-W

Evalution Of A Finite Element Model Of The THOR-NT Dummy In Frontal Crash Environment

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Daniel P. Malone, Rabih E. Tannous
AASA Inc., United States

Abstract:
The THOR-NT dummy has been developed and continuously improved by NHTSA to provide manufactures an advanced tool that can be used to asses injury risk in crash tests. With the recent improvements of finite element (FE) technology and the increase of computational power, a validated FE model of the THOR-NT provides an efficient tool for design optimization of vehicles and their restraint systems. The main goal of this study is to assess the current version of THOR-NT FE dummy model in the frontal crash environment. A three-dimensional (3D) FE model of the dummy was developed in LS-Dyna based on the drawings of the THOR-NT dummy. The material properties of the deformable parts and the properties of joints connecting rigid components were derived from the impact test data. To provide validation data for the assembled dummy model, two 40 km/h sled tests were conducted with the dummy restrained by a standard belt system and positioned in a rigid seat with the legs constrained at the knees. The upper body kinematics of the dummy was recorded by means of a 3D motion capture system that tracked the movement of retro-reflective markers attached to the dummy and to the buck. The dummy model fidelity was quantitatively assessed by comparing the displacement time histories of upper body and the reaction forces from the crash simulation with the corresponding data from the sled test. While the relatively low score of the model (0.55 - on a scale from 0 to 1) suggests the need of additional model improvements and validations under different test conditions (e.g., different shapes of deceleration pulses, and initial velocities), its reasonable performance in the direction of sled deceleration during 40 km/h frontal crash event would recommend it for use in impact simulations intended to improve the design of new vehicles and their restraint systems.

Paper No. 0279-W

Evaluation Of The Performance Of Competitive Headforms As Test Tools For Interior Headform Testing

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Federal Highway Research Institute (BASt), Germany
Felix Hänel
University of Applied Science Aachen Germany on behalf of APROSYS SP1

Abstract:
The European Research Project APROSYS has evaluated the interior headform test procedure developed by EEVC WG 13, representing the head contact in the car during a lateral impact. One important aspect within this test procedure was the selection of an appropriate impactor. The WG13 procedure currently uses the Free Motion Headform as used within the FMVSS 201. The ACEA 3.5 kg headform used in Phase 1 of the European Directive and the future European Regulation on Pedestrian Protection is still discussed as a

possible alternative.

This paper reports work performed by the Federal Highway Research Institute (BASt) as a part of the APROSYS Task 1.1.3. The study compares the two headform impactors according to FMVSS and ACEA, in a series of basic tests in order to evaluate their sensitivity towards different impact angles, impact accuracy, the effect of differences to impactors of the same type and the effects of the repeatability and reproducibility of the test results. The test surface consisted of a steel tube covered with PU foam and PVC, representing the car interior to be tested. Despite of the higher mass of the FMH the HIC values of this impactor were generally lower than those of the ACEA headform. The FMH showed a higher repeatability of test results but a high sensitivity on the angle of roll, the spherical ACEA impactor performed better with regards to the reproducibility. In case of the ACEA impactor-, the angle of roll had no influence.

Paper Number 09-0288-W

Development Of New Airbag System For Rear-Seat Occupants

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Abstract:
In addition to seatbelts, most vehicles today are fitted with airbags in the front seats as restraint devices for protecting occupants in frontal collisions. However, various constraints in the rear seats have prevented progress in adopting the same type of airbag system as that used in the front seats. Therefore, a new airbag system has been developed as a crash energy absorbing device to improve protection of the head and neck of rear-seat occupants. This new airbag system can be installed under the traditional constraints present in the rear seats.

Paper Number 09-0295-W

Protection System For Farside Occupants In Lateral Crashes

Benedikt Heudorfer, Michael Kraft
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Abstract
Although modern vehicles are equipped with multiple restraint systems such as airbags and seatbelts, there would be a further possibility to reduce occupant injury in even the best-pick category vehicles. The protection systems are mainly designed for occupants that are positioned closest to the intrusion. However, side-impact field data show approximately one-quarter to one-third of severely injured occupants sit on the far-side of the vehicle, furthest from the intrusion.
This study presents a novel protection system which is placed between the two front passengers to protect them from injuries caused by far-side impacts. The fixation of the performance-added airbag to the seat is designed in a pivot-like method to ensure a laterally stiff protection element, minimizing the excursion of the occupant's torso and head. The concept is designed to incorporate only minimal changes to existing seat and seatbelt designs. With reference to field data accidents, different impact angles have been sled tested under LINCAP conditions.
Results show a high benefit of the proposed Mid-Mount Bag. Keeping the occupants on their

own side of the vehicle as much as possible can mitigate many injuries caused by the vis-à-vis interior or by other occupants. The total torso excursion could be reduced by 45% compared to scenarios without adequate far-side protection.
With regard to the field data, approx. 70% of MAIS3+ far-side injuries can be avoided by the Mid-Mount Bag. Although installing additional airbag systems will have a cost impact, this impact is balanced by potentially saving numerous lives. The Mid-Mount Bag brings us closer to our dream of having zero victims due to traffic accidents.

Paper Number: 09-0296-W

Dynamic Side Impact Testing With The 50th Percentile Male Worldsid Compared To The ES-2RE

Allison E. Louden
National Highway Traffic Safety Administration, United States

Abstract
The agency released the final rule for Federal Motor Vehicle Safety Standard (FMVSS) No. 214 "Side Impact Protection" in September 2007, which put in place upgrades that involve moving deformable barrier (MDB)-to-vehicle and vehicle-to-pole crash tests with a 50th percentile adult male, the EuroSID 2re (ES-2re) and a 5th percentile adult female, the SID-IIs dummy. Recently, the National Highway Traffic Safety Administration (NHTSA) began evaluating the 50th percentile male WorldSID in these types of crashes using the same fleet vehicles. This paper includes an evaluation of the dummy's durability in crash testing and gives a comparison of the test results with those of the ES-2re dummy. The two dummies have different anthropometries and seating procedures which affect the final results. In general, the WorldSID produced more elevated responses than the ES-2re dummy for both test modes.

Paper Number 09-0298-W

New Programm For The Assessment Of Child-Restraint Systems (NPACS) – Development/Research/Results – First Step For Future Activities?

Volker Sandner, Andreas Ratzek, Dr. Reinhard Kolke
Allgemeiner Deutscher Automobil Club (ADAC), Germany
Werner Kraus (Chairman of NPACS), Dr. Maximilian Lang
Österreichischer Automobil Club (ÖAMTC), Austria

Abstract:
The protection of children in traffic, especially in cars, is one of the most important tasks facing our society. Children in cars are dependent on the assistance of their parents to provide them with adequate protection through the use of child restraint systems (CRS). Good advice to parents on how to use and fit CRS properly and which CRS offers the best protection are essential.
In Europe, due to the use of differing assessment criteria and rating schemes, the information provided to parents has been very confusing to date. Since there are still major differences in CRS use within EU member states, increased consumer information is a predominant European task.
The largest single advantage gained from this EU project "New Program for the Assessment of Child Restraint Systems" is that all members of the NPACS Project, representing the

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Governments of four European countries, research institutes, ICRT European consumer organizations and FIA automobile clubs, have cooperated to develop a scientifically based EU-wide harmonised test program and rating procedure. This program covers advanced test criteria in frontal and side impact, as well as comprehensive United Statesbility tests to reduce the potential for CRS misuse; misuse has been the predominant problem with CRS use for years. In addition, the NPACS procedure has not only been developed as to help parents and other purchasers of CRS, but also to encourage child seat manufacturers with their current and future designs, encourage new technologies to be brought to the market and to reduce the potential for misuse of their products.

Paper Number: 09-0304-W

Crash Adaptive Vehicle Structures And Components

Dr. Matthias Nohr, Karl-Heinz Blume,
DAIMLER, Sindelfingen, Germany

Abstract:
Daimler firstly introduced PRE-SAFE® applications in the S-Class, 2002. Up to now sensor information is used to bring front seats in a crash optimized position, to close windows and sunroofs, to eliminate the risk of penetrating objects, to prestress restraint systems and to activate braking systems in advance of a physical impact.
Future PRE-SAFE® applications are under investigation at the Research and Development Lab of Daimler. In cooperation with suppliers and Research Institutes crash structures have been developed which can be adapted to the individual impact scenario. In general the strengthening of vehicle BIW-structures can be introduced for frontal impact scenarios as well as for side impact scenarios.
The benefits of pressurized front and side members and door components have been evaluated. In general pressurizing is done by gas generators. These components are comparable to state of the art gas generators which are used for airbag applications. Within a few milliseconds the pressure increases up to 20bar. Depending on the initial shape of the structure, pressurizing can force an increase of the cross section and moment of inertia. Various door beam designs have been investigated. Pressure increased the initial cross section by about 200%. Component and vehicle tests were conducted to assess the repeatability of beam deformation, to emphasis benefits and to set up validated simulation tools.
Using simulation tools active BIW-structures have been assessed for frontal and side impact scenarios.
Having pre-crash triggered crash structures available, an impact on vehicle crash performance, passenger protection and weight reduction is expected.

Paper number: 09-0329-W

Evaluation Of Advanced Compatibility Frontal Structures Using The Progressive Deformable Barrier (PDB)

SUnited Statesn Meyerson, Christopher Wiacek
National Highway Traffic Safety Administration, United States
Pascal Delannoy
Teuchos, SAFRAN Group - UTAC Passive Safety Department
Guillaume Robert
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Abstract:
Vehicle compatibility combines aspects of both self and partner protection. Self protection involves a vehicle's compartment strength and occupant protection systems. Partner protection involves vehicle design attributes that work towards providing occupant crash protection of a vehicle's collision partner. Research has suggested that good engagement of the front structures and high compartment strength could be effective components for improving compatibility between passenger cars and other vehicles [1]. Studies have shown, however, that incompatible force distributions and greater relative front end stiffness are prevalent in the fleet. To research this issue, the Progressive Deformable Barrier (PDB) was evaluated for its ability to assess the compatibility between the front end force of vehicles equipped with and without compatibility countermeasures. The paper investigates self protection and partner protection in the offset frontal crash test configuration using the data produced by a joint research program carried out at the Union Technique de l'Automobile du Motocycle et du Cycle (UTAC) in conjunction with the Directorate for Road Traffic and Safety (DSCR) in France and the National Highway Traffic Safety Administration (NHTSA) of the United States (U.S.). The program was initiated to investigate whether barrier deformation using the PDB, intrusion, and dummy injury measures could differentiate compatibility performances between vehicles with and without advanced frontal structures designed specifically to address vehicle compatibility.

Paper Number 09-0363-W

Validation Methodology On Airbag Deployment Process Of Driver Side Airbag

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Duk Byung Chae
KOSTECH, Korea
Jae Hyung Kim
KOLON, Korea

Recent years the numerical method of the simulation for the airbag deployment process has been improved with new material model and thermodynamic model, and has become a standard application of finite element codes. With such simulation tools, it is possible to attempt supporting the airbag module design and evaluating the injuries of dummy in airbag hazard area or out-of-position. Although the simulation model for the airbag's deployment process is usually correlated with the static airbag deployments and reaction force results, up-to-date the numerical approach to represent the fluid flow within the airbag is both costly and time consuming. This paper will provide an overview of the correlation process for reducing the resource to be invested. The following two tests are conducted for acquiring the reference data. 1. Static deployment test for acquiring the airbag internal pressure during the deployment process and 2. Drop tower test for acquiring the fully deployed airbag's reaction force. The drop tower test is simulated to determine the parameter related to the leakage of fabric and vent holes with the airbag model using the uniform pressure method offering the relatively short solving time. And then Static deployment test is simulated for determining the parameter related to the unfolding phase with the airbag model using the corpuscular (particle) method. These two simulations are compared to the test results and satisfactory correlation is found in both the cases. The drop tower simulation using the uniform pressure method leads to reduce the total correlation time and to easily extend the application for protection of the driver occupant while in-position. This airbag model can be used in

parametric studies to investigate the effects of airbag module design changes and to study the out-of-position (OOP) load case.

Paper 090403-W

The Influence Of Subframe Geometry On A Vehicle's Frontal Crash Response

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SAFER Vehicle and Traffic Centre, Chalmers University of Technology, Gothenburg, Sweden

Abstract
The importance of a vehicle subframe is often discussed in vehicle compatibility. To observe how the subframe geometry influences the vehicle response, three different subframe configurations were modeled and simulated in US NCAP crash test configurations as well as car car simulations. The former simulations were used to observe how the design changes would influence self protection in a crash test influencing the original design of the vehicle. The latter simulations were to observe how the modification would influence vehicle compatibility under "real world" conditions.
The rigid barrier impacts could detect the changes in the design. The most forward placement of the subframe had a stiffer response than the other configurations as observed in acceleration pulse and barrier wall loads. Self protection also tended to be improved over the baseline configuration. In car car testing, it was difficult to identify a clear subframe configuration that provided improved compatibility. Both the standard and forward placed subframe had better performance than the most rearward configuration. Neither the baseline nor extended subframe versions were clearly better for all carcar impact configurations but an extended subframe exhibited better self protection, especially when the vehicle was lower than its collision partner.
Recent years the numerical method of the simulation for the airbag deployment process has been improved with new material model and thermodynamic model, and has become a standard application of finite element codes. With such simulation tools, it is possible to attempt supporting the airbag module design and evaluating the injuries of dummy in airbag hazard area or out-of-position. Although the simulation model for the airbag's deployment process is usually correlated with the static airbag deployments and reaction force results, up-to-date the numerical approach to represent the fluid flow within the airbag is both costly and time consuming. This paper will provide an overview of the correlation process for reducing the resource to be invested. The following two tests are conducted for acquiring the reference data.
1 Static deployment test for acquiring the airbag internal pressure during the deployment process and
2 Drop tower test for acquiring the fully deployed airbag's reaction force. The drop tower test is simulated to determine the parameter related to the leakage of fabric and vent holes with the airbag model using the uniform pressure method offering the relatively short solving time. And then Static deployment test is simulated for determining the parameter related to the unfolding phase with the airbag model using the corpuscular (particle) method. These two simulations are compared to the test results and satisfactory correlation is found

in both the cases. The drop tower simulation using the uniform pressure method leads to reduce the total correlation time and to easily extend the application for protection of the driver occupant while in-position. This airbag model can be used in parametric studies to investigate the effects of airbag module design changes and to study the out-of-position (OOP) load case.

Paper Number 09-0411-W

Development Of A Computational Model Of The Worldsid 50th Male

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Ebru Taylak Victor Oancea
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Sebastian Stahlschmidt, Alexander Gromer
DYNAmore GmbH, Germany
André Berger, Charles Thibaud
ESI Group, Germany

Abstract
Today the numerical simulation is an inherent process of the development of the passive safety of vehicles. So it is understood that every state of the art dummy has a virtual counterpart. Based on the positive experiences of the development of high quality dummy models within FAT working groups, German automobile manufacturers, represented by PDB, and the software vendors Dassault Systèmes SIMULIA, DY-NAmore and ESI Group decided to develop a high quality WorldSID 50th FE model. It will be available for Abaqus, LS-DYNA and PAM-CRASH.
The WorldSID programme was initiated to develop an advanced worldwide accepted dummy of improved biofidelity to access the injury risk to occupants in side impacts.
The finite element model of the WorldSID is based on the latest production version of the physical dummy. Its FE mesh was developed by using the technical drawings of the dummy and additional scans of dummy parts.
At first, it was necessary to identify the material properties of the dummy parts. An extensive test programme was started to obtain the required data. All materials were tested quasi-statically and dynamically. The material samples were taken from dummy parts and custom-built material plates.
The first release of the model includes the geometry and the material properties. It is used to design set-up and boundary conditions of component and sled tests to validate the components as well as the complete model. A large number of tests of different types of loading for neck, thorax, lumbar spine, pelvis and arm were conducted to obtain data for the validation process. The overall response and kinematics of the dummy is validated by using sled tests with different rigid barriers.
The final release of the model will be published in 2010. Pre-releases of the model will be available till then.

Paper Number: 09-0416-W

NHTSA's Recent Test Program on Vehicle Compatibility

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Abstract:
The objective of this study was to understand the structural interaction in frontal collisions between a compact passenger car and different Option 2 light truck based vehicles (LTVs). Vehicle-to-vehicle (VTV) crash tests were conducted to understand how these new concepts perform. Full frontal VTV crash tests into Model Year(MY) 2002 Ford Focus were conducted with the MY2006 Ford F-250 secondary energy absorbing structure (SEAS) attached and with the SEAS removed. Full frontal VTV crash tests into Focus were also conducted with the MY2006 Honda Ridgeline and MY2007 Chevrolet Silverado with the SEAS attached only. Ridgeline and Silverado SEAS are fixed below the rails and can not be removed like F-250. The results of these tests are presented and discussed in this paper. The largest LTVs are being equipped with new frontal structures to prevent override with passenger cars and it cannot be properly evaluated with the current full frontal barrier test. A new instrumented rigid override barrier (ORB) concept has been developed to evaluate the strength of SEAS and tested for this purpose. This paper summarizes and discusses the design and testing of the ORB.
Furthermore, Finite Element (FE) models of MY2006 Ford F-250 and MY2007 Chevrolet Silverado were developed by the National Crash Analysis Center at the George Washington University under a contract with National Highway Traffic Safety Administration (NHTSA) and Federal Highway Administration (FHWA). The structural interaction in frontal collisions between a compact passenger car and the two LTVs was investigated using computer simulations.

Page Number: 09-0422-W

Design And Optimization Approaches To Provide A Frame For Designer In The Vehicle Development Phase With The Focus On Enhanced Safety

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Abstract:
The safety of a vehicle is today of great importance for the automotive industry. The light weight vehicle designs are to increase in worldwide over the next years with respect to environmental and road safety regulations to make surface transport safer and more effective. The vehicle design models are usually complex in nature and nonlinear in terms of computational issues. The design and optimization in the area of transport are usually challenging tasks due to the highly nonlinear behaviour of structural parts with respect to durability, crashworthiness and vehicle dynamics issues. The design optimization process is usually limited by the excessive costly computational requirements in case of nonlinear model simulations and with respect to the difficulties for efficient exploration of multi-objective design space in the area of vehicle safety research such as crashworthiness. Although some studies which are given in literature have been carried out to solve the safety problems such as crashworthiness, they have not been efficiently solved yet. Recently, significant research in the area of vehicle safety and light weight vehicles through simulation based optimization undertaken, and it is expected to continue further resulting in reductions

in cost and time for new vehicle development process. The purpose of this paper is to explore design optimization approaches for development of light weight cars to satisfy safety needs for automotive structure and its components. In this paper, the shortcomings of traditional approaches, new design optimization approaches, stochastic and intelligent approaches that can be implemented to handle complex and nonlinear models are presented to provide a frame for designer in the vehicle development phase with the focus on enhanced safety for lightweight vehicles in the automotive industry.

Paper No. 09-0423-W

Characteristics Of Small Overlap Crashes

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Abstract:
Small overlap frontal crashes occur when vehicles are loaded outboard of their longitudinal structural members. Studies from the 1990s as well as current research have found that these crashes continue to account for a significant percentage of all serious frontal crashes. The National Automotive Sampling System/Crashworthiness Data System database was used to study the characteristics of these crashes in current model vehicles for drivers with injuries (excluding extremity injuries) rated 3 or greater on the abbreviated injury scale. Cases were individually analyzed to only include vehicles in which the majority of the loading was located outboard of the left longitudinal member. Occupant compartment intrusion was the primary factor in the resulting injuries, showing a strong correlation between the magnitude of intrusion and injury severity. Results suggest that vehicle designs must improve their ability to prevent occupant compartment intrusion when a vehicle is loaded at the outboard edges of its front end.

Paper Number 09-0466-W

A Validated Oblique Pole Side Impact Sled Test Method For Analyzing Occupant Response

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Nissan Technical Center North America Inc. United States
Doug Stein
Autoliv North America, United States

Abstract:
This paper describes a new test methodology for evaluating occupant injury response in a near side oblique pole impact per FMVSS 214. Given the complexity, time, and cost of using full vehicle pole impact crash tests to develop occupant restraint systems, it is desirable to have a simple test method that allows engineers to develop an optimized restraint system in a timely and cost effective manner. The authors will present a new sled test method that accurately simulates a full vehicle oblique pole side impact test using only minimal vehicle components. This test method was validated using both the ES2RE representing an AM50 occupant and a SID IIs representing an AF05 occupant. The authors will provide data showing correlation with full scale oblique pole impact vehicle tests. Furthermore, to demonstrate the effectiveness of this test methodology a case study will be presented showing a restraint system that has been optimized for both AM50 and AF05

occupants in an oblique pole impact.

Paper Number 09-0467-W

Development Of A Countermeasure Airbag To Minimise The Risk Of Serious Injury From Interaction With An Adjacent Occupant Or Far-Side Interior In Side Impact Crashes

Joon-Geun Cha, Il-Sang Kim
Hyundai Motor Company, Republic of Korea
Thomas Belcher, Suzanne Tylko, Ola Bostrom, Hee Loong Wong
Australian Government, Transport Canada, Autoliv Research, HMCA

Abstract:
In current production vehicles, passive safety systems for the protection of vehicle occupants exposed to side impact crashes have primarily been designed to reduce the risk of injury to the occupant seated on the struck side of the vehicle from interaction with the intruding structure and/or external objects. However, occupants involved in side impact crashes may also be injured due to interaction with an adjacent occupant, and a single occupant seated on the non-struck side of a vehicle may be injured due to interaction with the vehicle far-side interior.

This paper reports on the results of a 32 km/h full scale vehicle-to-pole side impact crash test conducted using a small hatchback vehicle mounted on a carrier sled at 75 degrees to the direction of travel. A single WorldSID dummy was positioned on the non-struck side of the vehicle and a countermeasure airbag was deployed on the inboard side of each front row seat. The countermeasure airbags used in this test are designed to provide side support to vehicle occupants involved in side impact crashes to limit lateral excursion and reduce the likelihood of serious injury due to interaction with an adjacent occupant or vehicle far-side interior.

The results of this single occupant test are compared to results obtained from an earlier investigation of occupant-to-occupant interaction, in which the countermeasure airbags were observed to reduce the risk of head injury from occupant interaction. In the single dummy occupant test reported in this paper, the countermeasure airbags successfully prevented the dummy from interacting with the pole and intruding far-side interior of the vehicle.

Paper Number 09-0475-W

Rear Seat Occupant Protection In Far Side Crashes

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Abstract:
The risk of being injured in side impact crashes is very high. Accident statistics show that numbers of vehicle occupants severely injured or killed of non-struck side occupants is approximately 30 percent. Based on accident data from the National Automotive Sampling System/Crash Data Study (NASS/CDS) an investigation concerning injuries and their levels

of non-struck side occupants in side impact crashes was carried out. From the accident data, covering the years from 1998 to 2007, the injured body parts, their injury levels and the vehicle parts causing these injuries were analysed. The study showed that hard contacts between the occupants and the rigid vehicle parts cause most severe injuries. As a result of the accident analysis an occupant protection concept for non-struck side occupants on vehicle rear seat was designed. A numerical simulation model representing a non-struck side occupant, its vehicle environment and the airbag based protection system was set up to investigate different parameters, such as airbag shape and position, different dummy types and seating positions. Prototypes of the airbag concept were built and validated in sled tests. The study showed that this occupant protection concept is able to reduce the severity of head and chest injuries of non-struck side occupants in side impact accidents. Furthermore, a positive effect on the interaction between rear seated occupants in side impact crashes was observed.

Keywords: Side crash, airbag, rear seated passengers

Paper Number 09-0480-W

The Minicars RSV – Still A Car For The Future

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Abstract:
Nearly a half century ago, the General Motors Research Laboratories, developed the high performance Electrovair, with an induction motor drive and solid state controller; the Lunar Rover, GM's Mark on the Moon; passive occupant protection; separation cruise control; optical lane following; and an electrochemical rechargeable Lithium Iodine engine.
In 1968, a new company called Minicars grew out of this earlier work. This group developed prototype electric, gas and hybrid electric powered versions of a small car for the U.S. government. In 1970, Minicars was a subcontractor to AMF for the development of its Experimental Safety Vehicle.
The Minicars' Research Safety Vehicle (RSV) was conceived in 1975 as a 1985 prototype. It was to be an S3E vehicle: Safe, Environmental, Efficient and Economical. It was built with foam filled, thin wall sheet metal sections and a polyurethane skin. This car passively protected occupants in 80 kph (50 mph) full frontal, 129 kph (80 mph) half car offset frontal, 64 kph (40 mph) angled side, rear and 48 kph (30 mph) rollover dynamic tests. An electronic version incorporated antilock brakes, radar separation cruise control, and emergency braking when a crash was unavoidable. A production version was to weigh 2,200 pounds, carry four people, and get 32 mpg. It also had 16 kph (10 mph) frontal and rear no damage bumpers and 80 km (50 mile) run flat tires.
Only years later have advanced air bags – as featured in the RSV – become standard in all light vehicles. In the decades since the ESV program and dynamic regulatory testing began, National Highway Traffic Safety Administration (NHTSA) now estimates that airbags save 2,500 lives annually, but we still lose about 12,000 people in frontal, 9,000 in side and over 10,000 in rollover crashes. We can do better by simply looking back to what the RSV program achieved.

Paper 09-0550-W

Technical Session
Developments in Frontal/Side Impact Protection

Uniform Application of NASS CDS Child Safety Data Definitions and Data Extraction

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Abstract:
The authors hope to provide an intermediate method of data extraction, taking advantage of the improvements in child passenger data collection and recording. The authors also wish to highlight the importance of appropriate United Statesge of the data As suggested in the Eigen 2007, the enhanced data set SAS files, also known as the 30-file data set, will be contrasted with the 11-file data set format, the traditionally available NASS CDS SAS files, and analysts will be referred to the NHTSA web site for supplementary information. Further, frequently asked questions will be addressed to provide uniform information dissemination to all users. The primary data source will be the National Automotive Sampling System (NASS) Crashworthiness Data System (CDS). As conclusion, the authors propose a three-step extraction methodology to be used until the enhanced data files can be released. This includes traditional data extraction to retain weighting factors, extraction of the enhanced variables, attributes, and associated graphics, and manually integrating the two data sources.

Paper Number 09-0556-W

Updated Analysis Of Lower Extremity Injury Risk In Frontal Crashes In The United States

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Abstract:
Injuries to the lower extremities continue to occur in frontal crashes despite increased attention on vehicle structure and restraint design. Since lower extremity injuries can lead to costly rehabilitation and long-term disability, it is important to understand their caUnited Statestion and how well modern design practices are affecting their incidence and severity. This study investigates lower limb injury risk and caUnited Statestion in a U.S. crash database, and compares the risk and severity based on the nature of the crash and vehicle specifications. This study uses weighted NASS-CDS data to give an overall view of lower limb injury risk over a period from 1994 until 2007. Crashes will be categorized by intrusion level, delta-V, and vehicle model year. Particular interest will be paid to leg, foot and ankle injuries as well as occupant factors and intrusion levels.
A review of the representative data suggests that foot and ankle injury prevalence has not decreased in newer model-year vehicles, and that injury risk to the foot and ankle has actually increased despite structural improvements aimed at reducing footwell deformation. When broken down by delta-V, the trends vary, but the majority of the injuries occur at lower crash severities. Although vehicle structures and restraints have been optimized for improved performance in consumer information and regulatory tests, the risk of sustaining lower extremity injuries, especially to the foot and ankle, remains an issue that deserves further attention.

Written Papers

Technical Session
Vehicle Stability and Control Systems, and Rollover Prevention

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Paper Number 09-0086-W

Subjective And Objective Evaluation Of An Outrigger Construction's Effect On Rollover

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Automotive and Power Train Engineering/Helmut Schmidt University, Germany

Written Papers

Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

Paper Number 09-0070-W

GPS, Communication And Environmental Sensor Based Collision Mitigation System For Trucks

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Abstract:
In order to enable state of the art and future accident preventing systems (APS) to react appropriate in traffic situations, it is essential to monitor the driving environment. Therefore a new communication, GPS and environmental sensor based method for APS data acquisition was developed. This method uses GPS, vehicle related driving dynamics data, wireless car-2-car-communication (C2C) and combines them with on-board environmental sensor data (Camera and Lidar sensors). First a Kalman-Filter based GPS-tracking was developed in order to increase the update rate of GPS. Therefore GPS- and vehicle dynamics data are fused in a dead reckoning system. Second, a Kalman-Filter based 3rd order lane model was implemented using Camera data from ego- and preceding vehicle - transmitted by C2C - for the determination of the relevant target. Beyond vehicle related data are transferred from the target vehicle to the ego-vehicle in order to improve the target selection. The potential of this method was demonstrated in a prototype collision mitigation (CM) system. The system was tested within driving experiments and subsequent simulations with the measured data. With the new method the accuracy and scope of application of collision mitigation systems can be enhanced, so that the detection and identification of stationary vehicles, for example at the end of traffic jams, is improved. Furthermore a high reliability of the determination of the relevant target for APS can be reached. As a matter of course the limitation of this approach is the dependency of the system performance (as in all C2C and environmental sensor based systems) on the equipment rate. On the other hand it can be expected that equipment rates will increase in future.

Paper Number 09-0207-W

Universal Medical Rescue Protocol Changed: "High Speed Auto Crash" Changed to "High Risk Auto Crash" in the Field Triage Decision Scheme.

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Technical Session
Integrated Safety Approach: From Prevention To Severity Reduction, Protection and Post-Crash Safety

Abstract:
At a crash scene, EMS providers must not only determine the severity of injury and initiate medical management, but also identify the most appropriate transport destination facility through a process called “field triage.” Proper decision making has a very significant impact on the outcome of injured subjects. Step III of the Field Triage Decision Scheme addresses mechanisms of injury and previously included “High Speed Auto Crash” as supported by initial estimated speed >40 MPH, major auto deformity >20 inches and intrusion into passenger compartment > 12 inches.
To take into account recent changes in trauma systems development and vehicle safety engineering and telemetry capabilities, the universally used Field Triage Decision Scheme was revised by a National Expert Panel organized by the Centers for Disease Control and Prevention. An extensive review of published evidence as well as analysis of crash injury databases was performed. New criteria targeted a 20% positive predictive value for Injury Severity Score greater than 15 (ISS>15) since more severely injured patients benefit most from transport to the highest level of trauma care. “High Speed Auto Crash” was revised to “High Risk Auto Crash” as supported by intrusion >12 inches at the occupant site or >18 inches anywhere in the vehicle as well as field telemetry consistent with high risk of injury. Rollover events and prolonged extrication were removed as criteria while death in the same occupant compartment was retained. The occupant ejection criterion was changed to specify both partial and complete ejection.
The recent revision of the universally used Field Triage Decision Scheme has potential to greatly improve rescue and treatment of crash injury victims. The addition of “vehicle telemetry consistent with high risk of injury” provides a tremendous opportunity for the automotive and medical communities to work co-operatively to improve crash safety.

Paper Number 09-0478-W

Field Test Of A Cooperative Intersection Collision Avoidance System For Violations (CICAS-V)

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Abstract:
The design objective of the Cooperative Intersection Collision Avoidance System for Violation (CICASV) project is to create a system that presents a timely and salient in-vehicle warning to those drivers who are predicted, by means of an algorithm, to violate a stop-sign or signal-controlled intersection. An on-road test was conducted to evaluate the CICAS-V using naïve participants to demonstrate that all systems are mature for a Field Operational Test (FOT). Data were evaluated from 72 naïve drivers representing both genders and three age groups who were placed into CICAS-V equipped vehicles to navigate a 2-hour prescribed route through equipped intersections in Virginia. During the prescribed route, drivers crossed 10 stop-controlled and 3 signal-controlled intersections equipped with CICAS-V making a variety of turn maneuvers through each for a total of 52 intersection crossings. The rate at which drivers received correct, false, and missed warnings was evaluated. Results indicate that the algorithms for both stop-controlled and signalized intersections were effective and that the prototype CICAS-V is mature for large-scale tests with naïve drivers. Participants in the study who received warnings rated the CICAS-V very

favorably and felt that the system would be beneficial. Recommendations were made for continuing with an FOT. Furthermore, the methods for conducting the study were determined to be suitable for an FOT. This study marked the first field test of the CICAS-V with naïve drivers. Project participants included offices of the United States Department of Transportation, Daimler, Ford, General Motors, Honda, Toyota, and the Virginia Tech Transportation Institute.

Written Papers

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

Paper Number 09-0116-W

Evaluating Recent Seat Models In Rear-End Impacts According To Currently Discussed Consumer Test Proposals

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Markus Muser
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Abstract:
To ensure a high safety standard of vehicle seats in rear-end collisions, consumer tests will include specific test standards. The prevention of soft tissue neck injuries is meant to be addressed by the introduction of such standards. To date particularly EuroNCAP has developed a detailed proposal how such seat tests should be conducted to assess the risk of whiplash associated disorders. In this study the relevance of the different parameters included in the consumer test proposal for assessing seat performance under rear-end impact conditions was analysed. A series of sled tests according to the latest proposal were performed with different seats. The performance of the seats was assessed as suggested by the proposal. In a next step a sensitivity analysis was conducted to investigate the influence of the different parameters on the final score.
Based on our findings it is suggested to modify the test procedure such that criteria which are redundant or have a weak biomechanical foundation are omitted. The sensitivity analysis revealed that the final score and thus the discriminatory power of the evaluation scheme will persist such that the assessment procedure will still be able to rate the performance of the seats.

Paper Number 09-0334-W

Modeling And Prediction Of Occupant Knee-Thigh-Hip Injuries

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Abstract:
Although extensive modeling efforts have been made in the past decades to predict occupant/pedestrian knee-thigh-hip (KTH) injuries, prediction for the injuries at the tissue level for various loading conditions observed in automotive crashes is still challenging. This study develops model-based tissue injury criteria and a tool to predict occupant KTH injuries subject to different postures and loading rates.
An effective plastic strain based injury criterion with a defined universal threshold was developed for identification of the potential injury locations in the KTH body region. The published cadaver KTH low-rate impact tests at three postures of neutral, adduction, and

flexion by UMTRI (University of Michigan Transportation Research Institute) have been simulated with the Takata 50th% male human model. Using the defined criteria, the model predicted the hip-bone and hip-joint fractures for the three postures, were well correlated to those observed from the tests. The KTH impacts were also simulated at two loading rates. The simulation results indicated a possible mode shift of the impact rate-associated injury with assumptions of viscous effects on hip-joint. A high rate impact more likely generates a fracture at the femur shaft; and the impact at a lower rate more likely fractures the hip-joint. The validated KTH injury criteria and tool were thus applied for accident reconstruction of two vehicle crash cases (full frontal and offset frontal impacts) selected from the NASS/CDS & CIREN database, which caused occupant KTH injuries at AIS 2-3 scale. The simulations match the injury outcomes of the reported field observations.

Paper number 9-335-W

Evaluation Of The Risk Of Injury Caused By A Knee Airbag In Out-Of position

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LAB PSA Peugeot Citroën RENAULT, France
Guy Vallancien
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Abstract:
As of today, active knee bolsters called knee airbags are available in some vehicles. However no assessment of the risk in Out-of-Position (OOP) conducted on Post Mortem Human Subject could be found in the literature. In total, 3 tests were performed in OOP on the Hybrid III 50th percentile dummy and 2 on two 50th percentile PMHS using a rigid subsystem based on the geometry of a commercially available mid-size European vehicle equipped with a knee airbag. The distance between the tibia and the airbag module ranged between 55 and 67 mm on the Hybrid III and was equal to 53 and 54 mm on the PMHS. The tests conducted on Hybrid III resulted in tibial drawer measurements in good agreement with the injury assessments since no injury was observed except bruises and abrasions (AIS 1). The results from the tests were compared to 36 real world frontal accident cases reported in France where drivers sustained only AIS 1 injuries (abrasion, contusion and bruise) during knee airbag deployment. The conclusions of this study are limited by the size of the sample (only 2 PMHS). However, the consistency between the outcome of the dummy and PMHS tests and the information from real world accidents provides a good confidence in the very low risk of injury associated with the knee airbag tested in OOP. Furthermore, the use of the Hybrid III dummy and the knee injury criteria based on the tibial drawer was appropriate in the tests conducted.

Paper 09-0362-W

Comparison Of Anthropomorphic Test Dummies With A Pediatric Cadaver Restrained By A Three-Point Belt In Frontal Sled Tests

Joseph Ash, Yasmina Abdelilah, Jeff Crandall, Dan Parent
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Chris Sherwood

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

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Dimitrios Kallieris
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Abstract:
Validation data for assessing dummy child biofidelity are limited, especially with regard to whole-body kinematics. Therefore, the goal of this study was to assess the kinematic biofidelity of current child dummies relative to results obtained from analysis of a child cadaver sled test. The baseline data were obtained from a previously unpublished test performed with a 13-year old pediatric cadaver restrained by a three-point belt. The cadaver test conditions were reconstructed using two dummies with anthropometry closest to that of the cadaver, the HIII 10-year old and HIII 5th female dummies. Due to anthropometric and age-equivalent differences between the dummies and the child cadaver, geometric scaling was performed on the signals based on the seated height and material properties. Kinematic evaluations of head, hip, and knee trajectories were obtained from film analysis. Accelerations of the head, shoulder and lap belt loads were measured and compared among the dummy and child cadaver data. While this study shows that the HIII 10-year old, scaled HIII 5th female and scaled pediatric cadaver reasonably agree for the shoulder belt force, the resultant head acceleration, and the maximum head excursion, differences in kinematics were identified between the dummies and the cadaver. Some of these differences in dummy kinematics were attributed to nonbiofidelic motion of the rigid thoracic spine with extensive bending at the cervical and thoracic spine junction. In addition to new cadaver data, the study provides insight into the applicability of geometric scaling for dummy evaluation and suggestions for improved dummy biofidelity.

Paper Number : 09-0392-W

Three Years Old Child Head-Neck Finite Element Modeling. Simulation Of The Interaction With Airbag In Frontal And Side Impact

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Abstract:
This study proposes to assess the interaction between the 3 years old child Head-Neck system and a typical airbag, a protective system frequently used in the automotive field. Two separated models (Head and Neck) developed at the Strasbourg University (UDS) were coupled in order to estimate the injury risk during this type of impact. The first model developed is a three years old child Finite Element neck Model (FEM) based on a realistic geometry (Meyer et al. 2008). This FEM was validated in four directions against an original method based on scaling method (Irwin et al. 1997). The second FEM is a 3 years old Head FE model published by Roth et al. in 2008. This model proposed an injury criterion in terms of Von Mises stress in the brain for moderate neurological injuries. After a coupling of these two FE models two impacts a frontal and lateral impact configuration is simulated. These impacts consisted of an airbag deployment at different gaps in order to calculate and estimate child brain injury risks.

Paper Number: 09-0402-W

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

Analysis Of 3d Rigid Body Motion Using The Nine Accelerometer Array And The Randomly Distributed In-Plane Accelerometer Systems

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Abstract:
The nine accelerometer array sensor package is used extensively in injury biomechanics research to obtain the rotational acceleration time histories of a rigid body. It has been shown in the past to remain computationally stable while the alternative, the six accelerometer array, becomes unstable in the presence of small inaccuracies in the individually measured accelerations. The nine accelerometer array process achieves its stability by requiring the measurement of three rotational accelerations, thus eliminating the six accelerometer array's dependency on having knowledge of the rigid body's three rotational velocities at each instant in time. The nine accelerometer array's additional three measurements also provide other important benefits: 1. Identifying whether or not any one of the nine translational acceleration measurements is inconsistent with rigid body motion, 2. If an incorrect acceleration is found, determining what the actual time history should be for that case, 3. Use of optimization methodology to obtain the best possible solution for the rigid body motion. This paper presents the derivation of an additional set of constraint equations that a given set of nine linear accelerations must satisfy to be consistent with rigid body motion, demonstrates how an inconsistent acceleration input is discovered, and describes the process by which the true time history of the acceleration is recovered. In addition, optimization methodology is introduced to obtain the best possible solution for a randomly distributed in-plane accelerometer system when errors in measurements are artificially introduced.

Paper Number 09-0420-W

Biofidelity Of The Worldsid Small Female Revision1 Dummy

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Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

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Abstract:
In the EC FP6 Integrated Project Advanced Protection Systems, APROSYS, the first WorldSID small female prototype was developed and evaluated by BASt, FTSS, INRETS, TRL and UPM-INSIA during 2006 and 2007. Results were presented at the ESV 2007 conference (Been *et al.*, 2007). With the prototype dummy scoring a biofidelity rating higher than 6.7 out of 10 according to ISO/TR9790, the results were very promising. Also opportunities for further development were identified by the evaluation group. A revised prototype, Revision1, was subsequently developed in the 2007-2008 period to address comments from the evaluation group. The Revision1 dummy includes changes in the half arms and the suit (anthropometry and arm biomechanics), the thorax and abdomen ribs and sternum (rib durability), the abdomen/lumbar area and the lower legs (mass distribution). Also a two-dimensional chest deflection measurement system was developed to measure deflection in both lateral and anterior-posterior direction to improve oblique thorax loading sensitivity. Two Revision1 prototype dummies have now been evaluated by FTSS, TRL, UPM-INSIA and BASt. The updated prototype dummies were subjected to an extensive matrix of biomechanical tests, such as full body pendulum tests and lateral sled impact tests as specified by Wayne State University, Heidelberg University and Medical College of Wisconsin. The results indicated a significant improvement of dummy biofidelity. The overall dummy biofidelity in the ISO rating system has significantly improved from 6.7 to 7.6 on a scale between 0-10. The small female WorldSID has now obtained the same biofidelity rating as the WorldSID mid size male dummy. Also repeatability improved with respect to the prototype. In conclusion the recommended updates were all executed and all successfully contributed in achieving improved performance of the dummy.

Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

Paper Number 09-0432-W

Dynamic Response Of Head Under Vehicle Crash Loading

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Abstract:
In this paper, a three-dimensional (3-D) nonlinear finite element (FE) method is used in association with the Articulated Total Body (ATB) biodynamics method, to study the human brain response under dynamic loading. The FE formulation includes the detailed model of the skull, brain, cerebral-spinal fluid (CSF), dura mater, pia mater, falx and tentorium membranes. The brain is modeled as viscoelastic material, whereas, a linear elastic material model is assumed for all other tissue components. Proper contact and compatibility conditions between different components are assumed. Instead of direct contact, inertial load resulting from the acceleration and deceleration of the head mass system is implemented. The ATB biodynamic package is used to simulate real vehicle impact scenarios, and to extract the six translation and rotation acceleration data at the center of the mass of the head component. These six-degrees of freedom (6-DOF) kinematic descriptions are used to represent the inflicted inertial loadings. The magnetic resonance imaging (MRI) outcomes, from two incidents with head impact, are compared with the biomechanical FE simulations to present the model capabilities. To examine and verify the material parameters used in FE formulations, experiments are conducted on a simulated brain material made from silicon dielectric gel. The results support that the combination of the FE deformation analysis and the ATB rigid body model is an effective method in head impact analysis and traumatic brain injury (TBI) identification.
Keywords: head impact, traumatic brain injury (TBI), Articulate Total Body (ATB) Model, dynamic analysis, three-dimensional (3-D) finite element (FE) model

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Paper Number 09-0506-W

Development of Response Corridors for the Compressive Stiffness of the Male and Female Arm in Lateral Loading

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Abstract:
The biofidelity of side impact ATDs is crucial in order to accurately predict injury of human occupants. Although the arm serves as a load path to the thorax, there are currently no biofidelity response requirements for the isolated arm. The purpose of the study was to characterize the compressive stiffness of male and female upper arms in lateral loading and to develop corresponding biofidelity stiffness corridors. This was accomplished by performing a series of pendulum tests on sixteen isolated upper arms, obtained from four male and four female cadavers, at impact velocities of approximately 2 m/s and 4 m/s. The

upper arms were oriented vertically with the medial side placed against a rigid wall in order to simulate loading during a side impact automotive collision. The force versus deflection response data was normalized to that of a 50th percentile male or a 5th percentile female and then response corridors were developed. For both impact rates the cadaver arms exhibited a considerable amount of deflection under very low force, i.e. toe region, before the any substantial increase in force. The deflection at which the force began to increase substantially was found to be similar to the average difference in thickness between the initial and compressed volunteer arm thickness measurements for both the 5th percentile female and 50th percentile male. Although the response of the SID-IIs arm was similar in shape to that of the female cadaver arms for both impact rates, the SID-IIs arm did not exhibit a considerable toe region and therefore did not fall within the response corridors for the 5th percentile. The results of the current study could lead to an improvement in the overall biofidelity of side impact ATDs by providing valuable data necessary to validate the compressive response of ATD arm independent of the global response.

Paper Number 09-0546-W

OOP Air Bag Tests With The Fifth Percentile Female Thor And Hybrid III Dummies

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Abstract:
The THOR-05F is a new anthropomorphic test device with many notable features, including a biofidelic neck design with built-in lordosis that segregates load paths within the cervical spine. Static air bag deployment tests were carried out with the dummy positioned in the NHTSA-1 (chin on module) driver Out-Of-Position (OOP) configuration. A set of late-model two-stage air bag modules were used in a total of forty tests, including reference tests conducted with the 5th percentile female Hybrid III dummy. All of the modules were driver-side units, and each was contained within its own steering wheel assembly. Half of the modules were configured to deploy more aggressively. All bags were observed to deploy asymmetrically, resulting in a substantial twist of the head about the z-axis of the THOR-05F neck, and a high corresponding Mz upper neck moment. The THOR-05F demonstrated its ability to discriminate air bag aggressiveness, especially in its upper neck tension measurements which was the most predominant upper neck load. Compared to Hybrid III, the THOR-05F neck showed less tendency to go into extension. The upper neck moment (My) and shear (Fx) were much lower in magnitude than those of the Hybrid III 5th. Head accelerations were similar to those produced by the Hybrid III 5th.

Paper No. 09-0557-W

Test Program To Define Oblique Chest Loading In Side Impact

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Technical Session
Biomechanics: Injury Criteria and Virtual Test Procedures/Tools Development

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Abstract:
Near side impact crashes – especially pole impacts – have the potential to induce antero-lateral oblique loads to the chest. Current side impact dummies and most laboratory experimental studies have been designed to assess direct lateral impacts. A recent analysis of real world crashes indicated that the human chest experiences oblique loading in side impact crashes – in particular crashes into narrow objects. This paper describes the development of a new sled test program to determine the oblique impact response of the human and to evaluate dummy biofidelity in an oblique mode of loading. The program involves the use of chestbands on dummies in full-scale vehicle tests accompanied by sled tests with unembalmed post mortem human subjects (PMHS). Sled tests are run under varying load wall conditions with a buck configured specially to mimic dummy loading seen in the vehicle tests. The chestbands provide comparative measures of thoracic deformation. Ultimately, the chestband measures will help establish the instrumentation requirements of an ATD for use in a side impact test with a significant oblique component. Additionally, this work could help introduce more biofidelic injury metrics for side impact ATDs

Written Papers

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

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Paper Number 09-0144-W

STREET: A Novel Simulator For Driver Assistance System Evaluation

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Abstract:
In order to evaluate the impact of driver assistance systems under various situations, researchers have attempted to reproduce accurate traffic situations and accidents by traffic simulations. Here, we propose a new simulator *STREET* (Safety & Traffic REaltime Evaluation Tool) that has a driver model with a cognition model and a decision-making model in it. This paper mainly describes the aim and the architecture of this novel driver model.

In the cognition model, there are three stages: 1) detecting objects in the field of view, 2) classifying such objects like a lead vehicle or oncoming vehicle, etc., and getting information, and 3) setting the driver's gaze direction. In the decision-making module, there are two stages: the first stage is to decide a maneuver for each recognized object by using "a decision rule with maps" expressed as the status space region defined by object's parameters such as distance and velocity as axes. The second stage is to decide the most appropriate maneuver among the combinations permitted in the acceleration/deceleration ranges for each object in succession to the first stage. The driving maneuver is switched in sequence based on the decision-making model output and the vehicle motion is then consequently calculated. When the traffic participants are added in the scene, decision-making rules are added for them, allowing *STREET* to correspond to complex traffic situations.

Two benefits are expected by using *STREET*. One is that users can evaluate and understand system activation under the target situations. Another is that the system can be evaluated under various traffic situations beyond the target situations so that the users can assess the limitations of the system. Some preliminary results using *STREET* and further development plans for the system are also discussed.

Paper Number 09-0222-W

Evaluation Of The Safety Benefits Of Passive And/Or On-Board Active Safety Applications With Mass Accident Data-Bases

Tobias Zangmeister
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Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Jens-Peter Kreiß
Technische Universität Braunschweig,, Germany
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RENAULT, France
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Abstract:
One of the main objectives of the European TRACE project (Traffic Accident CaUnited Statestion in Europe, January 2006 – June 2008) was the development of methodology for the evaluation of the safety benefit of existing on-board safety applications in passenger cars with the use of mass accident data-bases only.
The challenge was to evaluate passive safety applications as well as active applications and especially combinations of the two within a single investigation. In order to do so the well known concept of odds-ratio has been generalized for jointly evaluating injury mitigating effectiveness as well as accident avoiding effectiveness at once.
This paper describes statistical sound methodology that is able to evaluate the safety benefit of either a single on-board safety function or the additional gain of specific safety feature(s) (i.e. a selection of various passive safety functions and active safety functions), given that some other safety applications already are on board. In particular, the method allows for evaluation of accident avoiding effectiveness as well as injury mitigating effectiveness. Hence, it can be applied for joint evaluations of passive and on-board active safety applications.
The focus of the paper lies on the presentation of a ready-to-apply methodology, including detailed examples as well as a discussion on its advantages and its limitations.

Paper Number 09-0259-W

Safety Impact Methodology (SIM): Evaluation Of Pre-Production Systems

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August Burgett, Gowrishankar Srinivasan, Raja Ranganathan
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Abstract:
This paper describes a basic framework for Safety Impact Methodologies (SIM) to estimate potential safety benefits of pre-production advanced Driver Assistance Systems (DAS). A common flow-chart, showing the interaction between data United Statesge, crash scenarios development, model development, testing, data generation, and benefits estimation activities, is used to describe the basic framework. Although the framework applies to all types of evaluation of DAS, this paper focuses on those aspects that support evaluation of pre-production systems.

The paper then describes three approaches to implementing the SIM framework for pre-production systems. Two of these approaches describe effectiveness in terms of reduction in number of crashes with the system active. The third approach describes the effectiveness in terms of fatality and injury reduction, rather than estimating crashes avoided.

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The paper concludes with descriptions of how the three approaches are being implemented in the SIMs that are being developed by the four teams participating in NHTSA's Advanced Crash Avoidance Technology (ACAT) program. The paper also includes brief descriptions of other benefits evaluations as a means of highlighting how the framework accommodates evaluation of production systems and near-production systems as well as pre-production systems.

The framework developed in this paper provides a cornerstone for development of safety impact methodologies for evaluating pre-production driver assistance systems and for comparisons of methodologies that are used to evaluate production and near-production systems.

Paper Number 09-0312-W

Predictive Time-To-Lane-Crossing Estimation For Lane Departure Warning Systems

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Abstract:
This paper presents a data fusion algorithm which is able to robustly estimate the Time-to-Lane-Crossing (TLC) of a vehicle traveling along a lane on the basis of road images, collected by an on-board video camera, and kinematic data coming from car sensors. This algorithm is instrumental to built Lane Departure Warning Systems (LDWS) with enhanced predictive capabilities which allow the generation of earlier warnings able to better prevent dangerous driving situations coming from unintentional vehicle lane crossing occurrences. Comparisons with no predictive strategies are carried out and discussed in order to verify the effectiveness of the proposed approach in some critical driving scenarios simulated within the Carsim simulation framework.

Paper Number 09-0378-W

Speed Limiting Trials In Australia

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Vehicle Design and Research Pty Ltd
David Paine
Automotion Control Systems
Ian Faulks
Safety and Policy Analysis International, Australia

Abstract:

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Several trials of speed limiter devices are underway in Australia. The authors review these trials and estimate potential road safety benefits. This review builds on a paper that was prepared for the 20th ESV.
It was found that the technology is ready for widespread implementation. Extensive trials of ISA throughout the world have demonstrated the potential for significant accident savings as well as other community benefits.
There is a compelling case for governments to actively support ISA implementation.

Paper Number 09-0395-W

A Common Approach To Understanding Strengths And Limitations Of Different Cost Benefit Analysis Techniques

Tanya Smith, Iain Knight
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Abstract:
Policy makers require evidence of the costs and benefits of a safety measure to inform their views in policy decisions. These analyses are often required in a short period of time with limited research budgets. Increasingly, the measures considered are advanced control systems intended to help drivers to avoid a collision. It is inherently difficult to accurately assess the casualty effects of such systems and this, combined with resource constraints, often results in a wide range of conflicting predictions based on different assumptions, simplifications and analytical techniques. Substantial variation in the presentation of results can make it difficult for researchers to directly compare different studies. In turn, this makes it difficult for policy makers to be confident of the right approach. As a result, studies of very different levels of reliability are often given equal weight in policy debates, risking the possibility of less than optimal implementation of new safety features.
This paper describes the development of a methodology intended to allow a preliminary assessment of the potential benefits of advanced safety systems to be undertaken in a consistent and objective manner. An initial methodology was developed, based on literature and expert opinion, and then tested and refined by applying it to an assessment of existing studies of advanced braking systems for motorcycles.
The research was, therefore, limited to a relatively narrow scope. However, the potential for the method to be expanded in future was explored to assess the possibility of providing a generic methodology to provide guidance for policy makers and researchers alike regarding the:

Scientific confidence required from a new study or implied by existing analyses;
Suitability of different analysis techniques for the measure being assessed; and
Consistent presentation of results to aid subsequent comparison of different studies.

Page Number 09-0391-W

Vehicle-To-Vehicle Communication For Enhanced Integrated Safety

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Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Abstract:
Passive safety systems are reaching a limit in improving vehicle safety. Fundamental enhancement of passenger protection can only be obtained by including predictive, active safety systems. This field of development is termed integrated safety. A central step to tap the full potential of integrated safety is the expansion of this topic by vehicle-to-vehicle communication. The paper discusses the embedding of applications using vehicle-to-vehicle communication into an enhanced integrated safety concept. The main objective is to increase vehicle safety by using a proactive sensor which exceeds the physical limits of existing sensors and augments the context information for the driver. The development process is designed by including impartial and subjective characteristics and evaluations. The impartial part consists of, e.g., accident research, simulations and trial runs. The subjective part covers experiments with probands who have to evaluate the new safety concept with the upgraded information context for the driver, for example acceptance tests or human machine interface development. In addition to presenting the methodical development this paper discusses a first implementation of this method using as example the vehicle-to-vehicle communication. Expected results are rules and standards for the development of new enhanced integrated safety At first vehicles learned “to feel” - to detect a crash and to activate airbag systems. Today vehicle safety departments are developing cars which can “see”. The sense “seeing” is essential for the development of foresighted active safety systems to detect imminent accidents. In the future vehicles have to learn “to hear and to speak” using vehicle-to-vehicle communication. This will be a fundamental milestone for the integrated safety approach to prevent accidents and to decrease accident severity.

Paper Number 09-0436-W

The Effect Of ABS As A Preventive Safety Device: The Result Of Statistical Analysis Using Integrated Road Traffic Accident Database

Yasushi Nishida
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Abstract:
The object of this study is to evaluate the effect of Antilock Braking System (ABS) as a preventive safety device by statistical analysis of integrated road traffic accident database. The road traffic accident data including driver and road environment condition and the registered vehicle data including safety device were integrated. The risk of being struck from behind while stopping is not influenced by the driver characteristic of the struck vehicle. So the number of those vehicles/drivers is able to be considered a quasi-induced exposure, and the relative accident rates for some combinations of 7 factors listed later were calculated. Data of 253,035 cars, which were involved in a traffic accident from the year 2002 to 2007, manufactured from the year 1993 to 2000 and driven by a sober, private purpose and seat-belted driver, were analyzed by 7 factors; sex and age of driver, types of collisions, day/night, road surface condition, with/without a passenger and with/without ABS. ABS is expected to reduce the accident rate, especially for some collision types which could be prevented by keeping wheels unlocked. The results shows; 1) the accident reduction effect of ABS on wet road surface was greater than on dry road surface, and 2) ABS reduced the relative accident rates of a rear-end collision by 1-38% and an single vehicle collision by 10-33%. There are several discussions about the validity of the quasi-induced exposure

method. But the effect of ABS was confirmed by considering the interactive effect with other factors such as age of driver or with/without a passenger. Further studies are required for precise discussion. The developed integrated database and the proposed method are also useful to evaluate other preventive safety devices.

Paper Number 09-0438-W

Requirements And Data Sources Needed For Validation Of Component Properties And Performance In Simulation Based Benefit Assessment Of Driver Assistance Technologies

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UMTRI, United States

Abstract:
In one of the Advanced Crash Avoidance Technology (ACAT) projects, a computational simulation approach has been used to assess the potential benefit of three advanced Driver Assistance Technologies in a lane departure scenario. The main advantage of a computational simulation approach to driver assistance technologies evaluation is that a wide range of conditions can be explored at a comparatively low cost. Also, though multiple data sources related to traffic safety are available, few approaches make systematic and integrated use of them. Using them to validate simulation components provides a way of integrating data from various sources into a reUnited Statesble format.
When using simulation, the properties of each simulated component need validation. The objective of this paper is to describe data requirements for component validation, as well as how data which meet the requirements has been identified and extracted. The basic approach of the project is to look at each simulated component and determine which of its properties influence scenario outcome. Data sources which provide input on those properties are identified, and data from them is extracted and prepared for use in the simulation. To achieve a high level of detail and accuracy for all components, data from multiple sources are used including crash databases, field operational tests, testing on test-tracks and driving simulator experiments.
The research conducted in this project shows that sufficient data can be obtained to validate the properties of the simulation components. There are limitations in available data for some sources which raises questions of representativity, but these can in principle be overcome by extended data collection. The research also shows that while extensive effort may have to go into validation the first time a simulation is developed, similar subsequent projects will require much less validation effort since the simulation components can be reused.

Paper Number 09-0511-W

An Examination Of Crash Scenarios And The Potential Benefits Of Six Advanced Safety Technologies

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Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

Abstract:
NHTSA published the report "Pre-Crash Scenario Typology for Crash Avoidance Research", DOT HS 810 767, in April 2007. This paper reviews the data presented in this DOT report and will examine the data for patterns which may be useful in prioritizing safety technology strategies from a frequency, economic cost and functional years lost perspective. Furthermore, techniques are developed and presented which offer weighing methodologies which could be useful in ranking anticipated benefits of various advanced safety technologies currently coming to market. The paper concludes with calculated rankings of the six advanced safety technologies, discusses the ranking results relative to a similar calculated ranking of ESC and offers some observations regarding ESC behavior and potential unexpected safety benefits of ESC.

Paper Number 09-0532-W

How Tires Change A SUV's Performance In Fishhook And Sine-With-Dwell Testing

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Stephen M. Arndt
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Abstract:
A 2004 Chevrolet Tahoe was tested with the Original Equipment Manufacturer's (OEM) base and optional recommended tires and wheels, and two sets of different sized aftermarket tires and wheels. One aftermarket tire and wheel set used a much larger and wider rim with a low profile tire that did not significantly change the vehicle's Static Stability Factor (SSF). The second aftermarket tire and wheel set used the larger optional OEM rim with a larger than recommended Light Truck (LT) designated tire that significantly lowered the vehicle's SSF. Tests were performed pursuant to the protocols described in the United States Department of Transportation (USDOT) National Highway Traffic Safety Administration (NHTSA) New Car Assessment Program's (NCAP) fishhook and sine-with-dwell maneuvers. Results demonstrated that changes in vehicle performance due to the use of aftermarket tires were dramatic. The lower profile tire and wheel combination produced vehicle tip-up in fishhook testing at 40 and 35 mph with and without ESC enabled respectively. The larger LT tire and wheel combination did not produce vehicle tip-up in fishhook testing with ESC enabled, but did at 45 mph with ESC disabled. Both base and optional OEM tires produced test results which fell in between the two aftermarket tires. The vehicle successfully completed the sine-with-dwell test maneuvers with ESC enabled and failed with ESC disabled when equipped with either the base or optional OEM tires.

Paper 09-0559-W

Lane Departure Warning (LDW) Performance Evaluation

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Abstract:

Technical Session
Safety Performance and Effectiveness of Driver Assistance Technologies, Test & Evaluation Procedures, Benefits Assessment

This paper describes a test track based lane departure warning (LDW) evaluation performed by the National Highway Traffic Safety Administration (NHTSA). NHTSA defines an LDW system as one intended to alert the driver when their vehicle is about to drift beyond a delineated edge line of their current travel lane. LDW system alerts consist of audible, visual, and/or haptic warnings, or any combination thereof. The test maneuver described was designed to emulate a lateral drift while travelling on a straight road. This type of maneuver was chosen because it represents one of the most dominant pre-crash scenarios as reported in the 2004 General Estimates System (GES) database.
LDW performance was quantified by considering the vehicle's proximity and approach rate to the inboard edge of a single lane line at the time of the LDW alert. Variations in how the alerts were presented to the driver, and the manner in which the timing of the alerts changed as a function of the lateral velocity toward the lane line, were observed.

Paper Number: 09-0569-W

Assessment Of A Drowsy Driver Warning System (DDWS) For Heavy Vehicle Drivers

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Gregory M. Fitch, Ph.D., Joseph L. Bocanegra, M.S., Myra Blanco, Ph.D., Richard J. Hanowski, Ph.D.
Virginia Tech Transportation Institute, United States

Abstract:
Drowsiness has a globally negative impact on human performance by slowing response time, decreasing situational awareness, and impairing judgment. This paper reports the findings of a Field Operational Test (FOT) of an early prototype Drowsy Driver Warning System (DDWS). Fifty-three research questions were addressed related to performance, capabilities, acceptance, and deployment. The FOT included control and test groups utilizing an experimental design suitable for a field test. The dataset for the analysis consisted of 102 drivers from 3 for-hire trucking fleets using 46 instrumented trucks. Fifty-seven drivers were line-haul and 45 were long-haul operators. The data set contained nearly 12.4 terabytes of video, truck instrumentation, and kinematics data for 2.4 million miles of driving and 48,000 driving-data hours recorded, resulting in the largest data set ever collected by the U.S. Department of Transportation. When considering the operational window of the Driver Fatigue Monitor, results showed that the drivers in the Test Group had lower drowsy measurement values, and that drivers who received feedback from the system had an overall reduction of drowsy driver instances. Whereas, the experimental design was specified to support the statistical reliability of potential findings, the dataset was largely diminished from eyes-off-road time from driver distraction and normal mirror checking tasks, which were incorrectly sensed by this early prototype as drowsy episodes. As a result, no statistically reliable safety benefit was observed. However, novel data reduction procedures were able to extract data during the time periods in which the system was accurately detecting drowsiness, and analysis of these data indicated a slight reduction in critical unsafe driving events related to drowsiness. As a result, while there is some indication that a DDWS may be a promising concept, the particular prototype used in this field test to

implement the concept needs significant improvement and further study.

Paper Number 09-0570-W

Enhanced Camera/Video Imaging Systems (E-C/VISS) For Heavy Vehicles

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William A. Schaudt, M.S. Walter W. Wierwille, Ph.D., P.E. Richard J. Hanowski, Ph.D. Joseph Bocanegra, M.S.
Virginia Tech Transportation Institute, United States

Abstract:
Lane change and merge maneuvers represent approximately 20% of heavy truck crashes, resulting in loss of life and property damage. Tests were performed to determine the feasibility of developing an Enhanced Camera/Video Imaging System (E-C/VIS) to provide heavy-vehicle drivers with better awareness of their vehicle's position in relation to other vehicles on the roadway (situation awareness). It is well known that large blind spots currently exist in these areas. A previous phase of this program measured the field of view requirements for heavy trucks, resulting in an improved understanding of mirror performance and recommendations for the design of a camera based indirect viewing system. With indirect viewing requirements understood, the goal of the present research was to extend the operating envelope of a conventional video implementation of the requirements to nighttime and inclement weather conditions. A three-channel system was envisioned in which there would be a camera at each front fender of the tractor looking backward along the sides of the heavy vehicle. The third channel would be aimed rearward from the back of the trailer. Once developed, the three-channel system was tested in static and dynamic driving environments and it was found to work well in the nighttime and inclement weather environments, including various street lighting conditions.

Written Papers

Technical Session
(NEW) Effect of Fuel Economy Strategies on Vehicle Safety

Paper Number 09-0300-W

NHTSA Tire Rolling Resistance Test Development Project – Phase I

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James D. MacIsaac Jr.
U.S. Department of Transportation - National Highway Traffic Safety Administration, United States

Abstract:
This paper presents research results from the first phase of a project to develop a tire fuel efficiency consumer information program for passenger vehicle replacement tires. In this phase of the project, the agency completed a test program using 600 tires of 25 model/size combinations to evaluate five different rolling resistance test methods. These test methods were derived from two SAE and two ISO standards. The test matrix included two separate test laboratories to examine lab-to-lab variation.
The results indicated that all of the five test methods had very low variability and all methods could be cross-correlated to provide the same information about individual tire types. While multi-point rolling resistance test methods are necessary to characterize the response of a tire's rolling resistance over a range of loads, pressures, and/or speeds, either of the two shorter and less expensive single-point test methods were deemed sufficient for the purpose of simply assessing and rating individual tires in a common system. The single-point ISO 28580 draft international standard has an advantage over the single-point SAE J1269 recommended practice because it contains a lab-to-lab measurement result correlation procedure. There was a significant offset observed in the data generated by the two laboratories when using the identical test, even when testing the same tire, which must be accounted for in a rating system. Results show that for all the tests conducted, lab-to-lab variation can be statistically minimized if data from each lab is normalized to the test results of a Standard Reference Test Tire (SRTT). Two additional retests of a given tire did not produce statistically different rolling resistance values from the first test. So the concept of limited retesting of the same tires for lab alignment or data quality monitoring appears valid.

Written Papers

Technical Session
Rear Impact Injury Prevention & Protection

Paper Number 09-0029-W

Numerical Simulation For Evaluating Child Occupant Behaviour In The Case OFA Rear Impact

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FPInnovations
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Abstract:
This project uses dynamic simulations to assess the effectiveness of child restraint systems in the case of rear impact, in various installation configurations and for different acceleration pulses. The model was mainly based on a multi-body method, using the MADYMO software. However, the side wings of the child restraint system have been modelled by the finite-element technique, to ensure a better representation of the contacts between the child dummy and the restraining device. The study shows that the neck is the most exposed part of the body and in some situations the neck injury criteria overpass the limit values. Thus, the case of the neck injury criteria in tension-extension for the installation using vehicle safety belts, when the result is more than double than the limit value. The simulations employed two triangular pulses, with speed variation of 16 km/h and 25 km/h, and one trapezoidal pulse, with speed variation of 25 km/h. In all cases, the results are proportional with the speed variation. Furthermore, the two triangular pulses give higher values for injury criteria than the trapezoidal pulse. Installation of a child restraint using rigid anchorages and lower straps offers the best protection for the child passenger in the case of rear-end collision. The acceleration pulse is a crucial factor for the accuracy of tests and the realism of simulations. The principal limitation of the study refers to the injury criteria that are not yet well defined and for which does not exist a consensus in the case of a rear impact. The paper presents an approach for simulating rear-end collision involving child passengers, which could be used for comparative studies of different rear-impact scenarios, such as different acceleration pulses or installations.

Paper Number 09-0324-W

Influence Of Seatback Content And Deflection On FMVSS 202A Dynamic Response

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Abstract:
Automotive seat design requires knowledge of the structural response of the seat under various impact conditions as well as understanding the complex interactions between an occupant, seat content and restraint systems. For the case of rear impact collisions, the seat

becomes the primary restraint while seatback and head restraint design become increasingly important in mitigating the risk of occupant injury. This study involved the testing of three different seatback designs under FMVSS 202a dynamic conditions to determine the effects of seatback comfort content on occupant response and injury risk measures. Controlled variables include seatback content and seatback stiffness. Three different recliner stiffness values were simulated that resulted in nominal seatback rotation angles of 5, 10 and 15 degrees. Additionally, three different lumbar support mechanisms were tested, including a static suspension, horizontal lumbar support and vertical lumbar support. Results from the 18 tests conducted are presented and analyzed.

It is expected that the various comfort content will affect torso penetration into the seatback, altering the torso angle and therefore influence the resulting head with respect to torso angle. It is determined that seatback rotation (stiffness) and backset are predictors of head angle and that lumbar support type and foam stiffness affect the backset. The time of maximum head with respect to torso angle (determined as the critical event time) is influenced by seatback stiffness, lumbar support type and lower torso rebound. Both seatback stiffness and lumbar type are found to be good predictors of torso penetration. The amount of torso penetration and the rebound effect on torso angle at the critical time in the event are key findings. None of the independent factors are found to have a significant influence on HIC.

Written Papers

Technical Session
Human Machine Interface - Issues, Driver-Vehicle Interaction Related Research, Impaired Driving and Human Factors Guidelines Development

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Paper Number 09-0250-W

Driver's Mental Workload Assessment Using EEG Data in a Dual Task Paradigm

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Abstract:
The integration of physiological monitoring into the human–machine interface holds great promise both for real-time assessment of operator status and for providing a mean to allocate tasks between machines and humans based on the operator status. Our group, aiming to provide a new human-machine interface to improve traffic safety using brain signals, has conducted a number of researches for the driver states monitoring based on EEG data in recent years. This article presents our study for the representation of mental workload using EEG data. A simulated driving task - the Lane Change Task (LCT), combined with a secondary auditory task - the Paced Auditory Addition Serial Task (PASAT), was adopted to simulate the situation of in-vehicle conversations. Participants were requested to perform the lane change task under three task conditions - primary LCT, LCT with a slow PASAT and LCT with a fast PASAT. The EEG recordings combined with performance data from LCT and PASAT provided plenty information for comprehensive understanding of driver's workload. The analysis of event-related potentials (ERP) revealed that LCT evoked cognitive responses, such as P2, N2, P3b, CNV, and the amplitudes of P3b decreased with the task load. A crucial benefit of these findings is that the increase or decrease of amplitudes of ERP components can be directly used for representing driver's mental workload

Written Papers

Technical Session
Deployment Strategies of Safety Technologies – Voluntary Standards, Regulations & Ratings

Paper Number 09-0286-W

Development Of A Generic Assessment Systems

Mike McCarthy
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Abstract:
Advanced safety systems which use pre-crash sensing information from the environment and/or the vehicle occupants have an "active response" which improve primary or secondary safety. Many systems are in development which use pre-crash sensing information as a decision input and it is widely predicted that the implementation of such safety systems, together with appropriate actuators and control algorithms, offer significant safety potential.
Existing test methods evaluate the crash performance of a vehicle, but are unsuitable for the assessment of advanced safety systems because additional evaluations of the sensing performance and the effect of autonomous actions on the driver response are required. To meet this need, work package 1.3 of the European Advanced Protection Systems (APROSYS) project developed a generic methodology which was intended to define guidelines for development of a specific test programme. This paper presents the final generic methodology for advanced safety systems and details a 'test case' carried out to demonstrate the application of the methodology

Paper Number 09-0393-W

Demonstrator For Virtual Testing Procedure. Application To Pedestrian Adult Head Impacts

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Abstract:
The research activities presented in this paper were carried out within Sub-Project 7 of APROSYS (Advanced PROtection SYStems), a European Integrated Project implemented within the 6th Framework Programme which main objective is the development and introduction of critical technologies that improve passive safety for all European road users in all relevant accident types and accident severities. Furthermore, this IP aims to increase the level of competitiveness of the European industry by developing new safety technologies (safety is a proven selling point) and by developing design tools and evaluation methods that will increase the efficiency of the development process of the involved industries.
SP7 (Virtual Testing) deals with the development of knowledge and tools to facilitate the design and evaluation of advanced crash protection systems by virtual testing (numerical simulation). Within SP7 a Virtual Testing (VT) demonstrator based on a combination of

simulations and physical tests for pedestrian protection (head impact) was delivered. Where VT has proven to be predictive and where benefits in terms of increasing safety are expected.
In a first approach, experimental adult head form impacts against bonnet structures were performed. Besides, a series of virtual tests with standard adult head form numerical model and numerical model of the test rig were performed. VT was performed with limited data (only initial conditions) from physical test and no validation results were provided to adjust the nominal simulation model. Finally, a study of experimental testing variation using stochastic models was performed. The effects of these variations were quantified using stochastic analysis.

Paper Number 09-0445-W

Preparing The Future For Functional Safety Of Automotive E/E-Systems

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System Safety, Audi AG, Germany

Abstract:
The development of different sensor technologies and powerful signal processing procedures allows the automotive industry to develop new E/E-based safety systems, which may assist and protect drivers and also other traffic participants in very complex situations. The complexity of possible use cases for safety systems on the one hand generates on the other hand a variety of feasible safety concepts to prevent these systems from malfunctioning. But which safety concept is adequate for a specific safety system? It is not conceivable to standardize all possible safety concepts, but to give guidelines to the engineers of how to develop new safety concepts; the automotive industry has started to standardize the process of developing safety – related E/E systems. This paper gives insight into the ongoing standardisation work within ISO TC22/SC3/WG 16 functional safety and how companies have started to apply the draft standard and consequently how this standard may initiate the development of a new state of the art within the area of functional safety in the long term.

Written Papers

Technical Session
Structural Integrity and Restraint Performance

Paper Number 09-0186-W

Analysis And Prevention Of Child Ejections From Golf Cars And Personal Transport Vehicles

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Technology Associates
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Abstract:
United States Consumer Products Safety Commission statistics indicate there are approximately 13,000 golf car related emergency room visits in the United States annually. Of these, approximately 40% involve children (i.e. age < 16) and 50% of these involve a fall from a moving car. Evidence also indicates that many passenger ejections occur during left turns. Children are especially susceptible to ejection because of their small size and reliance upon the hip restraint for stability. While adult ejections have been studied, the present study analyzes mechanisms of child ejection during left turns. Dynamic tests are presented wherein an anthropomorphic Hybrid III 6 year old dummy in the front passenger seat is ejected during a moderate left turn and ejection kinematics are analyzed. An Articulated Total Body (ATB) occupant simulation is also presented, which compares favorably with experimental results. Additional simulations are presented wherein a seatbelt is found to be effective in preventing ejection with minimal belt force requirements. While experimental and simulated occupant dummies do not include muscular reactions, the potentially rapid onset of vehicle acceleration indicates that real occupants, particularly young children, may not have time to react before the ejection process has begun. Results indicate that current hip restraints are not large enough to prevent the ejection of small children during a moderate left turn. Additionally, seatbelts or straps are effective in preventing ejection during driver induced accelerations. The small belt force requirements indicate that seatbelts designed for use in automobiles and meeting Federal Motor Vehicle Safety Standards (FMVSS) may not be necessary. Based on these results, it is recommended that children be prohibited from riding in golf cars without a seatbelt type restraint when driven on golf courses and that seatbelt type restraints be provided for each occupant, especially children, when driving outside the golf course setting.

Paper Number 09-0471-W

USA Ambulance Crashworthiness Frontal Impact Testing

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EMS Safety Foundation, United States
Raphael Grzebieta
Injury Risk Management Research Center, University of New South Wales, Australia

Abstract:
Recent epidemiological studies have identified ambulances as high risk passenger transport

vehicles, particularly the rear compartment. It appears in the absence of UNITED STATES ambulance safety standards or guidelines, non engineer end-users are driving changes in practice and policy in place of independent peer reviewed biomechanical and crash injury outcome data. This study's objective is to compare and analyze frontal crash biomechanical and crashworthiness research for ambulance vehicles, with a focus on application of the real world environment, and development needs for future standards. Frontal impact ambulance crashworthiness tests conducted over past 15 years, were identified and evaluated with a multidisciplinary approach consisting of automotive crashworthiness, emergency medicine, public health and EMS care delivery. Crash test data identified include: 25G to 34 G deceleration sled tests (delta V 20.9 to 32.3 mph); one full crash test of a bullet vehicle travelling at 36 mph crashing into another vehicle, impact Delta V of 30 km/h (18.5 mph) and deceleration of 14Gs to the rear compartment; and three fixed barrier frontal tests at a 40km/h (25 mph) delta V and 25 G impacts. There appeared to be a lack of correlation with real world crash forces in the conduct of the rigid barrier tests. The use of data from side facing occupants was also confounding. Ambulance crashworthiness is a complex system. Clearly demonstrated hazards have been identified in the limited real world crash injury/fatality data and the crash test data available. Testing must be based on meaningful real world parameters such as the forces that occur in actual crashes and the types of injury and fatality hazards to the occupants, so that development of standards and thus the design and construction of ambulance vehicles, can be focused to achieve adequate levels of occupant protection using current crashworthiness methodology already utilized in industry.

Paper Number 09-0491-W

Computational Analysis Of A Near And Far Side Front Occupant Kinematics In A Vehicle Rollover With Different Restraints

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Abstract:
The Volvo XC 70 2001 model is used to conduct the full scale rollover crash test to determine the glazing and roof performance. The biodynamic code MADYMO is used to model the vehicle and its occupant. The acceleration obtained from the full scale rollover test is used to prescribe the motion to the computational model. The front side occupants are 50th percentile Hybrid III ATD's. A Finite Element belt model is used for the analysis because of its capability to simulate the slip of the occupant under the shoulder belt. The simulation is carried out with different restraint types to quantify the head lateral and vertical excursions. The restraint type includes the conventional three-point system, integrated restraint in which the belt is attached to the seat, and a restraint type in which an extra shoulder belt is added to a conventional and an integrated restraint. The driver and the passenger head kinematics are compared for each restraint type. A comparison is made for driver and passenger head excursion for different restraint types to demonstrate the effectiveness of each restraint in reducing excursion. The study indicates that an integrated seat belt results in less lateral and vertical head excursion, as compared to the conventional restraint. This study also indicates no significant improvement in reducing head excursion by the addition of an extra shoulder belt compared to a conventional or an integrated restraint.

Paper Number 09-0513-W

Vehicle Roof Geometry And Its Effect On Rollover Roof Performance

Technical Session
Structural Integrity and Restraint Performance

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Abstract:
The Jordan Rollover System (JRS) provides a realistic, highly controlled, repeatable dynamic test of vehicle roof crush performance under typical rollover conditions [1],[2]. The principal use thus far has been in comparing vehicles' roof crush and injury potential performance in one and two roll events. Because the JRS directly measures the force between the roof and the ground during touchdown, it can be used to measure, assess and optimize occupant protection by adjusting roof geometry, roof structural design and material strength and elasticity, for the least cost and weight.
This study demonstrates that the peak force (load) between the initial leading side roof rail (near side) and the road is roughly four times the vehicle weight (the load-to-weight ratio or LWR) when a vehicle first touches down at around 150º of roll. The force then drops substantially as the vehicle continues to roll over the flat of the roof, in most instances dropping to zero because the vehicle is momentarily airborne. When the vehicle rolls beyond 180º and comes into contact with the side rail opposite to the leading side of roll (far side), the force rapidly rises again. The roof then either collapses or lifts the vehicle center of gravity (COG). The far side rail of a weak roof vehicle that cannot lift the COG may then halt the vehicle's downward fall, imposing even larger forces on the road segment when the vehicle's door and main body structure interact with the roadway. To deal with such forces, a long standing and natural presumption has been to substantially increase the roof strength to weight ratio (SWR), which can result in weight efficiency cost penalties. However, one production vehicle that was tested minimized roof crush without substantially increasing its SWR.
Analysis of the results has found that far side roof crush is strongly related to the difference between the major radius (the maximum distance from the principal axis of rotation to the roof rail) and minor radius (distance from that axis to the center of the roof). Three to four inches, as between cars and LTV's has a significant effect on injury potential. The typical difference in a light truck vehicle LTV is around 15 cm to 25 cm (6" to 10") while in an passenger car it is around 8 cm to 15 cm (3" to 6").

These observations were confirmed by physical tests of strong and weak roofed vehicles. These tests led to the conclusion that a geometry change in the roof to minimize the difference in radius across the roof would reduce the degree to which the far side of a less strong roof had to lift the vehicle as it rolled beyond 180º. A finite element analysis confirmed that for a vehicle of modest roof strength, a structurally strong, rounded roof panel will reduce the far side deformation and intrusion speed by about two-thirds without increasing underlying roof strength. These results were confirmed in JRS testing of current production passenger cars and SUV vehicles and with a "HALO"™ – High Attenuation Load Offset (U.S. and International Patent Pending Rollover Damage Minimization Device) retrofit kit for SUVs.

Written Papers

Technical Session
Vulnerable Road Users: Pedestrian Safety

Paper Number 09-0027-W

Pedestrian Protection Using A Shock Absorbing Liquid (SALi) Based Bumper System

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Abstract:
Improving pedestrian protection in vehicle impacts is achieved by the combination of proper shapes and materials in vehicle front end design. This may however conflict with other priorities regarding vehicle impact performance, such as damageability. It would be advantageous to have a single bumper system design that meets global legislative impact requirements. Alternative materials may provide the solution.
The composite material described in this paper is a blend of elastomeric capsules or beads in a matrix of Newtonian fluid. The material, which can be considered as a liquid analogy to elastomeric foams, is referred to as shock absorbing liquid or SALi.
SALi based shock absorbers have the ability to change their energy absorbing properties depending on the type of impact (velocity and size of the impacting body) that they are cushioning. Based on this ability, SALi based shock absorber devices could be beneficial for impact energy management applications because of their attendant response tailorability. However, prior to adopting SALi based devices for impact energy management applications several key issues need to be resolved.
The present study was focused on one of the most significant of these: the verification of the tunability of the response of such devices at different stroking velocities. Impact tests using an assisted drop tower facility were conducted on SALi based energy absorbers for a range of impact velocities. The results of the experimental tests conducted on SALi based shock absorbers are encouraging. The material shows innovative energy absorbing properties. Interpretation of the results described here provide for a better understanding of the fundamental behaviour of SALi based energy absorbers and provide a first step tool in optimising the design of energy absorbing bumper systems.

Paper Number 09-0088-W

Development Of A New Flex-PLI LS-Dyna Model And Investigations Of Injury From Vehicle Impact

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Abstract:

Technical Session
Vulnerable Road Users: Pedestrian Safety

A new flexible pedestrian legform impactor (Flex-PLI) has been developed by Japan Automobile Manufacturers Association, Inc. (JAMA) and Japan Automobile Research Institute (JARI).
The new Flex-PLI has good biofidelity as well as several knee ligament elongation measurement capabilities, three femur and four tibia bending moment measurement capabilities. For these reasons Flex-PLI is likely to be adopted for the future pedestrian Global Technical Regulation.
This presentation introduces a finite element model of the Flex-PLI for LS-DYNA and presents a CAE (**C**omputer **A**ided **E**ngineering) study that investigates Flex-PLI kinematic behaviour caused by impact with a vehicle. The new Flex-PLI LS-DYNA model was carefully created to ensure that every important detail was included. Geometries, masses and material properties of all parts were reproduced from drawings and inspection of the real components. Connectivity and component interaction within the model were determined by thorough experiments. Accurate prediction of injury indices and kinematic behaviour was achieved by correlation to JARI's static and dynamic calibration tests. A fine mesh was used while reasonable calculation cost assured by imposing an analysis time step of 0.9 micro seconds.
In this report, investigations by computer simulation of Flex-PLI deformation behaviour mechanisms during vehicle impact are presented.

Paper Number 09-0146-W

Development Of A Biofidelic Flexible Pedestrian Legform Impactor Type Gtr Prototype Part2: Technical Details

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Abstract:
In 1998 the European Enhanced Vehicle-Safety Committee (EEVC) proposed a test procedure to assess the protection vehicles provide to the lower extremity of a pedestrian during a collision. This procedure utilizes a legform impactor composed of rigid long bones. In order to improve biofidelity of the legform impactor, the Japan Automobile Research Institute (JARI) and the Japan Automobile Manufacturers Association, Inc. (JAMA) have been developing a biofidelic flexible pedestrian legform impactor (Flex-PLI) since 2002. The Flex-PLI has high biofidelity especially for its long bone parts, which have human-like bending characteristics under a car impact condition, compared to other types of legform impactors, which have rigid long bone parts. The Flex-PLI also provides extended injury assessment capability, including long bone bending moment at multiple locations and knee ligament elongations in comparison to other pedestrian legforms.
In 2005, the Flex-PLI Technical Evaluation Group (Flex-TEG) was settled under the UN/ECE/WP29/GRSP/Informal Group on Pedestrian Safety in order to evaluate its performance to adopt the impactor as a regulatory purpose test tool for a Global Technical Regulation on Pedestrian Safety (PS-GTR: gtr 9). The Flex-PLI was evaluated and improved its performance under the Flex-TEG activity, and then its design of the final version, type GTR (Flex-GTR), was agreed by the Flex-TEG members in April 2008.
This paper provides technical details of the Flexible Pedestrian Legform Impactor GTR

prototype (Flex-GTR prototype). Technical specifications on all important aspects of the Flex-GTR prototype are given: dimensions and mass at (sub-) assembly level; biomechanical responses of main components of the femur, knee and tibia; calibration procedures and corridors; standard and optional instrumentation channels, their capacity and position; handling; including details of electrical systems and data acquisition. The paper will present results of calibration testing, repeatability and reproducibility of three prototypes which are evaluated at First Technology Safety Systems (FTSS) before their release from the FTSS factory.

Paper Number 09-0159-W

New Modular Assessment Methods For Pedestrian Protection In The Event Of Head Impacts In The Windscreen Area

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Abstract:
The head impact of pedestrians in the windscreen area shows a high relevance in real-world accidents. Nevertheless, there are neither biomechanical limits nor elaborated testing procedures available. Furthermore, the development of deployable protection systems like pop-up bonnets or external airbags has made faster progress than the corresponding testing methods. New requirements which are currently not considered are taken into account within a research project of BASt and the EC funded APROSYS (Advanced PROtection SYStems) integrated project relating to passive pedestrian protection.
Testing procedures for head impact in the windscreen area should address these new boundary conditions. The presented modular procedure combines the advantages of virtual testing, including full-scale multi-body and finite element simulations, as well as hardware testing containing impactor tests based on the existing procedures of EEVC WG 17. To meet the efforts of harmonization in legislation, it refers to the Global Technical Regulation of UNECE (GTR No. 9).
The basis for this combined hardware and virtual testing procedure is a robust categorization covering all passenger cars and light commercial vehicles and defining the testing zone including the related kinematics. The virtual testing part supports also the choice of the impact points for the hardware test and determines head impact timing for testing deployable systems. The assessment of the neck rotation angle and sharp edge contact in the rear gap of pop-up bonnets is included.
For the demonstration of this procedure, a hardware sedan shaped vehicle was modified by integrating an airbag system. In addition, tests with the Honda Polar-II Dummy were performed for an evaluation of the new testing procedure. Comparing these results, it can be concluded that a combination of simulation and updated subsystem tests forms an important step towards enhanced future pedestrian safety systems considering the windscreen area and the deployable systems.

Paper Number 09-0226-W

Technical Session
Vulnerable Road Users: Pedestrian Safety

Predictive Pedestrian Protection – Sensor Requirements And Risk Assessment

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Abstract:
In this paper an approach to predictive pedestrian protection is being proposed. The main issues regarding the identification of high benefit scenarios, the requirements for an appropriate risk assessment algorithm as well as the requirements for the environmental sensor system are discussed. A general survey of the topic is given first, including accident statistics regarding vulnerable road users. Based on more detailed accident data the requirements for a video-based pedestrian recognition system are derived. As a result the best suited aperture angle for early detection of pedestrians was determined. A possible approach for predictive pedestrian protection is to issue an adequate driver warning in case of an impending vehicle-pedestrian collision. In order to justify driver warnings it is necessary to calculate the collision risk with a relatively large time-foresight. To cope with this task a pedestrian motion model based on likely and possible accelerations has been developed.

Paper Number 09-0264-W

Pedestrian Collisions With Flat-Fronted Vehicles: Injury Patterns And Importance Of Rotational Accelerations As A Predictor For Traumatic Brain Injury (TBI)

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Abstract:
Research on pedestrian protection currently is focusing mainly on passenger cars. However, impacts with heavy goods vehicles (HGV) and buses are also important, especially in urban areas and in developing countries. This study is an attempt to show the distribution of injury patterns focused on the head injury mechanism. In the European project APOLLO WPII database with a number of 104 pedestrians injured by a HGV or bus were identified. The head was found the most severely injured anatomic region, with an average AIS of 3.1, followed by the abdomen/pelvis (AIS 2.9), and the thorax (AIS 2.1). Using the Dr. Martin transformation matrix, head injury mechanisms were assigned to codified head injuries. Around 69% of the sustained head injuries had a rotational injury mechanism, 21% translational, and 10% either. Three multi-body vehicle models, representing two HGV and one bus, were used in a large parameter analysis. The simulations showed that the angular velocity change is exceeding 30rad/s and the angular acceleration is exceeding 10.000rad/s² in simulations where the HIC value was below 1000. Additionally the head injury risk was assessed by prescribing the accelerations of the human pedestrian model's head to a finite element head and brain model. It can be concluded that head injuries are the most frequent

injuries sustained by pedestrians involved in a collision with a flat-fronted vehicle and rotational accelerations are responsible for around 70% of head injuries. Impactors currently used in pedestrian protection regulations do not assess rotation-induced injuries.
Keywords: Vulnerable Road Users, Pedestrian, Bicyclist, Heavy Goods Vehicles, Trucks, Head Injuries, Rotational accelerations, FE head/brain model

Paper Number 09-0276-W

Stationary Video-Based Pedestrian Recognition For Driver Assistance Systems

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Abstract:
As statistics have shown, forty-two percent of all injury accidents in Germany's road traffic happen at intersections. Infrastructure-mounted cameras for traffic analysis have been proposed to reduce this number as well as simulation tools, which assist in developing Car-to-Infrastructure (C2I) communication applications in the field of driver assistance, pedestrian, vehicle and traffic safety by a combination of a real application and virtual scenarios. This paper describes an infrastructure-based vision system for pedestrian and vehicle detection, its integration in the C2X-communication software development framework viilab and the visualisation to display the acquired data in a C2X-vehicle. Two cameras are used to monitor an intersection in the visible spectral range out of different views. With methods of computer vision and machine learning road users are detected and analysed as pedestrians or vehicles for both views. The merged objects' positions are transformed into world coordinates and tracks within the traffic trace are generated. The data can be used in a simulation or can be requested in real time from C2X enabled cars via a roadside unit (RSU) as an environment radar. The performance of the system is discussed.

Technical Session
Vulnerable Road Users: Pedestrian Safety

Paper Number 09-0323-W

The Heavy Goods Vehicle Aggressivity Index

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On behalf of the APROSYS WP 2.1 consortium

Abstract:
The provision of protection for vulnerable road users (pedestrians and pedal cyclists) is not a new concept for vehicle design. Directives 2003/102/EC [1] and 2005/66/EC [2] assess the "structural aggressivity" of passenger cars and front protection systems ("bullbars") with respect to the protection of pedestrians. Adopting these directives for assessing heavy goods vehicles (HGVs) would be straightforward. However, assessing the "structural aggressivity" only, will fail to address a relatively large number of fatalities, particularly those that occur at low-speeds. This manuscript describes the development of the test procedures and assessment criteria for the Heavy Vehicle Aggressivity Index (HVAI). The procedure and criteria are derived based on the study of real world accidents. The proposed procedure integrates numerical simulation and physical testing methods.
The HVAI aims to reduce the number or severity of vulnerable road user (pedestrian and pedal cyclist) casualties from accidents involving HGVs by providing guidance to manufacturers/designers of such vehicles.
The HVAI consists of three parts, assessing the field of view of the driver (active HVAI), the direct contact between the casualty and the vehicle structure (structural HVAI) and the risk of the casualty being over run by the HGV (run-over HVAI). Each of these sub-indexes returns a value between 0 and 10. The three parts ensure that a wide range of accident scenarios are addressed.
Keywords: Vulnerable Road Users, Pedestrian, Bicyclist, Heavy Goods Vehicles, Trucks

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Paper Number 09-0356-W

Design Analysis Of A Sandwich Hood Structure For Pedestrian Protection

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Abstract:

Technical Session
Vulnerable Road Users: Pedestrian Safety

Besides functioning as an engine compartment cover, the hood of modern vehicles can also help manage the impact energy of a pedestrian's head in a vehicle-pedestrian impact. However, a hood's ability to absorb impact energy may be impeded by the proximity of the hood to components packaged inside the engine compartment, i.e., by its underhood clearance. For example, for a given hood design, the hood's ability to absorb impact energy through deformation can be significantly reduced when the hood and engine block are in close proximity. Therefore, a large underhood clearance would be preferred for pedestrian protection. However, it could negatively affect driver visibility, as well as a vehicle's aerodynamics and aesthetic appeal. This paper presents a sandwich hood design that has a potential to improve the hood's ability to absorb the impact energy of a pedestrian's head with a relatively small underhood clearance. Using nonlinear finite element and the EEVC headform impactor models, a design analysis was conducted with an underhood clearance target of 60 mm and 75 mm for the child head impact area and the adult head impact area, respectively. A set of design parameters of the sandwich hood was optimized. The analysis shows that out of the 12 impact points covering the main hood area, about half of the impact points achieved Head Injury Criterion (HIC) values less than 800 and the others yielded HIC values between 800 and 1000.

Paper Number 09-0429-W

Pedestrian Injury Characteristics Following Road Traffic Collisions

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Abstract:
The paper outlines the nature and severity of the injuries suffered by pedestrians in motor vehicle accidents in England. Pedestrian admissions to hospitals in England as recorded in the Hospital Episode Statistics (HES) over a nine year period were compared with accidents recorded in Great Britain's national road casualties database (STATS19). Alongside this, the most frequently injured regions and individual injuries of the pedestrians were investigated. The relationship between individual injuries and the length of time spent at hospital was investigated. The changes in frequency of individual injuries were investigated to see whether recent changes in vehicle design could have altered the types of injuries received by pedestrian casualties.
The HES data from April 1998 to March 2007 in England contained details of 82,811 pedestrian admissions following accidents involving motor vehicles. In the same time period there were 65,526 killed or seriously injured pedestrians recorded in the STATS19 database. It was found that over the nine year period, the number of pedestrian casualties in HES remained relatively constant, while the number in STATS19 has reduced. In this period, HES data shows that tibia and femur fractures have reduced slightly. This could be due to a number of factors including improved vehicle design.
The nature of the HES data means that very little information is included about the characteristics of the accident, which prevents possible causes of pedestrian injuries to be studied using the HES dataset by itself. However, this paper shows the potential of hospital data as an important tool in accident research, as the injury information can give evidence of the effects of the changing vehicle fleet, along with other road safety interventions. Further,

through an in-depth understanding of the frequency and consequences of different injuries, future injury prevention strategies can be prioritised.

Paper Number 09-0489-W

Benefit Of "Dynamic Use Cases" To Early Design A Driving Assistance System For Pedestrian/Truck Collision Avoidance

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Abstract:
The common approach to express Driving Assistance Systems (DAS) functionalities is often based on use cases that explain driving context and required assistance. However, DAS design requires temporal consideration of driving situation evolution when using the assistance, in order to define when the assistance is activated and which decision criteria is used. Driving situation complexity and its temporal progress cannot be easily appreciated without tools taking into account all actors (pedestrians, driver, vehicles…) and assistance effects on the scenario evolution.

This paper describes a software application that offers designers a light and simple way to early design, tune and test DAS functioning on progressing situations. This tool is developed in the VIVRE 2 project to support the early design of a DAS that warns truck drivers to avoid pedestrian collisions. In this context, the tool permits to test the DAS functioning by running "dynamic use cases" (static use cases enriched with additional inputs to reflect the temporal evolution). It allows the designer to build scenarios with specifics parameters about driver, truck, pedestrians and assistance. It also proposes replay and trace features that help the analysis of the "dynamic use cases" combination. These iterative tests and adjustments of DAS allow determining decision criteria that works in all targeted situations.

To further efficient early design, the tool must stay light and easy to use. As a consequence, the temporal evolution models of actors are kept simple. Once the DAS functioning is validated, another design phase in more realistic conditions is required; to make sure that no unanticipated behaviour occurs, which may reduce the functioning.

This approach is crucial for early designing of a DAS to bring continuity to the use cases and to evaluate the consequences of any decision criteria modification on the global functioning in order to ensure driver warning efficiency

Paper Number 09-0504-W

A Study Of Bicyclist Accidents In Changsha Of China And Hannover Of Germany

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Technical Session
Vulnerable Road Users: Pedestrian Safety

Abstract:

Bicyclists represent a population with high risk of traffic injuries since they are unprotected in vehicle collisions. A study was conducted with an in-depth analysis of bicyclist accidents in China and Germany. The analysis is to identify the hazard of bicyclists in Changsha and to propose the way to reduce the number of these accidents and also severity of injuries. The analysis was carried out in terms of the causes of injury, injury severity and distribution and also type of vehicle involved, accident type, road environment, time distribution etc. The accident cases that occurred from 2001 to 2006 were collected from IVAC database in Changsha, China and GIDAS database in Hannover, Germany. Based on specified sampling criteria, 1,013 bicyclist cases and 1806 cases were selected from the two databases, respectively. Statistical analyses and comparative analyses were carried out with the sampling data. The results show that there were similarities and differences regarding bicyclist accidents between Changsha and Hannover, especially for the frequency and age distribution of the fatalities and also the road environment where accidents occurred. The results from this study suggested that there is a great potential for reduction of the accidents and fatalities by safety countermeasures, such as United Statesge of helmet and improvement of road environment in countries like China.

Keywords: bicyclist accidents, statistical analysis, circular distribution analysis

Written Papers

Technical Session
Advances in Vulnerable Occupant Protection Systems

Paper Number 09-0081-W

Concept Study Of Adaptive Seatbelt Load Limiter Using Magnetorheological Fluid

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Abstract:
Most current seatbelt load limiter technologies could only offer three or fewer predetermined patterns of seatbelt restraint force. However, researches have shown that, to better realize adaptive protection to different occupants under different crash severities, a continuously and real-time adjustable load limiter may be one step further. This concept could be especially favorable to vulnerable occupants such as small stature females and elderly people. Ideas have emerged suggesting possibility of using magnetorheological fluid (MRF) to realize such load limiter (MR-LL). This paper presents a concept study of MR-LL, aiming at evaluating its feasibility and establishing basic guidelines for prototype development. Configuration of an MR damper integrated with seatbelt retractor is selected in the study, in which the seatbelt force can be controlled by varying the strength of magnetic field exerted on the MRF inside the damper. The MR damper is numerically modeled and validated against experimental data found in the literature. Then by merging the MR damper model with a simplified occupant and seatbelt model subjected to sled impact loading, the performance of MR-LL under different parameter settings is studied and optimized. The simulation results demonstrate proof of the concept, indicating that the proposed MR-LL can generate various seatbelt force patterns with a wide adjusting range, thus to meet the requirement of both occupant adaptability and crash severity adaptability. Possible limitations of the proposed MR-LL are also discussed.

Paper 09-0484-W

Comparison Between New Data On Children Anthropometry And CRS Dimensions

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Abstract:
The objective of this paper is to compare the morphology of children aged from 3 to 15 years old with actual Child Restraint System dimensions. First, an anthropometry study has been

performed on about 2000 French children aged from 3 to 15 years old. For each subject, 15 external measurements have been acquired in particular in sitting position. They include classical dimensions like weight and heights (head-seat, shoulder-seat, etc) but also new data concerning for example the sternum length, the xyphoid angle or the thorax and abdominal widths. In a second step, 13 dimensions have been measured on about 30 actual CRS. These CRS concern only forward facing system such as booster seat and they represent the different standard groups: 0+,1, 2, 3. To complete the geometry acquisition, 6 dimensions concerning the back seat of 6 different vehicles have been measured. Dimensions have been focused in particular on the belt position in the car or in the CRS. For each child anthropometric dimension, the 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentiles curves are given and discussed. Then, these dimensions are compared with the measurements performed on the CRS and on the vehicles. In particular, data concerning the belt position regarding the children morphology along ages are detailed. The location of the belt on the shoulder is more specifically evaluated. Results highlight that some of the CRS appear as unsuitable regarding the children anthropometry. This article shows for example a gap between the CRS classification based on children weight.

Paper Number 09-0543-W

Characteristics Of Powered Two Wheelers Accidents Susceptible To Be Avoided And Minimized Through Adas And IVIS Implementations

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Abstract:
Powered Two Wheelers (PTWs) accidents constitute one of the road safety problems in Europe. PTWs fatalities represent 22% at EU level in 2006 [1], having increased during last years, representing an opposite trend compared to other road users' figures.
In order to reduce these figures it is necessary to investigate the accident caUnited Statestion mechanisms from different points of view (e.g.: human factor, vehicle characteristics, influence of the environment, type of accident). SAFERIDER project [2] ('Advanced telematics for enhancing the SAFEty and comfort of motorcycle RIDERs', under the European Commission '7th Framework Program') has investigated PTW accident mechanisms through literature review and statistical analyses of National and In-depth accident databases; detecting and describing all the possible PTW´s accident configurations where the implementation of ADAS (Advanced Driver Assistance Systems) and IVIS (In-Vehicle Information Systems) could contribute to avoid an accident or mitigate its severity.
DIANA, the Spanish in-depth database developed by CIDAUT, has been analyzed for that purpose. DIANA comprises of accident investigation teams, in close cooperation with police forces, medical services, forensic surgeons, garages and scrap yards. An important innovation is the fact that before injured people arrive to hospitals, photographs and explanations about the possible accident injury mechanisms are sent to the respective hospitals (via 3G GPRS

technology). By this, additional information to medical staff can be provided in order to predict in advance possible internal injuries and select the best medical treatment. This methodology is presented in this paper.
On the other hand, the main results (corresponding to road, rider and PTW characteristics; pre and post-accident manoeuvres; road layout; rider behaviour; impact points; accident caUnited Statestions;…) from the analyses of the PTW accidents used for SAFERIDER are shown. Only accident types relevant to ADAS and IVIS devices have been considered

Written Papers

Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Paper No: 09-0061-W

An Analysis Of Hospitalized Motorcyclists In The State Of Maryland Based On Helmet Use And Outcome

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Abstract:
In recent years, there has been a significant increase in mortality among motorcyclists. Despite high rates of morbidity and mortality associated with crashes among older riders, there have been relatively few studies on injured motorcyclists admitted to hospitals. In an ongoing study, data is being collected from motorcyclists involved in crashes in Maryland who were either killed or transported to the R Adams Cowley Shock Trauma Center (STC) in Baltimore, Maryland. Data on injured motorcyclists is captured from the trauma registry, hospital discharge records, autopsy reports, and through a linkage with police crash reports. Injured parties are assessed six-months and one-year post crash with the Short Form 36 (SF36) questionnaire. The SF-36 is an evaluation tool used to determine long term outcome. Autopsy reports are obtained from the Office of the Chief Medical Examiner of Maryland (OCME).
Previous studies looking at head injuries resulting from motorcycle crashes have not been able to discriminate between operators using helmets that are and are not compliant with standards set forth by the United States Department of Transportation (DOT). Helmets will be categorized as DOT-certified, full-face, half-shell or uncertified novelty helmets. Fatal versus non-fatal crashes with resulting injuries are compared and matched by operator demographics, helmet use and type, and crash characteristics. It is anticipated that persons involved in a crash while wearing an uncertified novelty helmet have a higher risk of head injury than those who crashed while wearing a DOT-certified helmet.
From January 2007 through May 2008 there were 517 motorcycle operators admitted to the STC. The mean age of this group was 37 years and 25percent sustained a head injury with an Abbreviated Injury Score (AIS) between 1 and 6. Twenty-one percent of these helmets were identified as DOT non-certified. A comparison of head injury and helmet type revealed that 50 percent (13/26) of those wearing a uncertified novelty helmet received a head injury (AIS 1-6) as compared to 23 percent (22/96) of those wearing a DOT certified helmet.($p<.05$).

Paper Number 09-0134-W

Commercial Vehicle Safety Technologies: Applications For Tire Pressure Monitoring And Management

Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

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Abstract:
Tire deficiencies often cause commercial motor vehicles (CMVs) to be cited for regulatory violations and to be taken out-of-service during roadside inspections. As part of a major safety technology project to assess the state of the practice and potential contributions of advanced sensor systems, the Federal Motor Carrier Safety Administration (FMCSA) sponsored three studies between 2003 and 2008 on tire pressure management systems (TPMS). The first study focused on obtaining baseline information. Fleet records and limited field collections were used to develop a database of inflation readings for 35,000 CMV tires, providing the first large-scale source of information on CMV tire inflation in the United States. The second study assessed the performance of TPMS in a controlled test-track environment. Multiple systems were installed on a truck tractor, a trailer, and a motorcoach. These were run under nominal operating conditions and with tire and system faults deliberately introduced. Although all the systems functioned at the levels specified by their manufacturers, some had limited ability to compensate for changes in ambient temperature, to reset pressure “alert” thresholds, and to withstand repeated tire installation and removal cycles. The third study, performed in an operational setting in an urban transit fleet, assessed the performance and maintainability of tire pressure monitoring devices. Three types of TPMS were installed on 12 buses that accumulated more than 1.28 million km, in aggregate, during the 12-month test period. The results of this study pointed to sensor durability and data integration challenges that need to be overcome for these systems to be used successfully in a severe service environment. These studies provided new information directly comparing the performance of TPMS in controlled and operational settings. Results are limited to the particular systems and applications tested. Study data are available from the FMCSA.

Paper Number 09-0205-W

Effectiveness Of Seat Belt United Statesge On The Rollover Crashworthiness Of An Intercity Coach

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Abstract:
Safety of vehicle occupants jeopardized during rollover accidents when necessary safety measures are not taken. Structural adequacy and protection of occupants are the two significant measures that can be implemented to minimize occupant injury risk during vehicular rollover events. The aim of this paper is to evaluate the structural resistance and passenger injury risks

and compare the effectiveness of safety belt United Statesge in occupant during a simulated rollover event of a 13 meter long TEMSA bus. A total of eight occupants were placed at the structurally weakest locations of the bus. Three different occupant protection cases were considered:
i. no safety belt, ii. two-point safety belt and iii. three-point safety belt. A standard rollover procedure was simulated using non-linear finite element code LSDYNA. Head injury criteria and neck forces were calculated and compared to evaluate the effectiveness of seat belt United Statesge on occupant protection. Simulation results clearly illustrated that when occupants had no seat belt protection they suffered serious risk of injuries. Moreover, two and three point safety belts provided somewhat similar protection levels for most of the occupants. Based on the findings, use of two point safety belt in all of the seats of the TEMSA busses was recommended.

Paper Number 09-0213-W

Influence Of Alcohol Concentration And Braking Procedure On Motorcylist Brake Reaction Time Using A Motorcycle Riding Simulator

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Abstract:
The statistical data published by National Police Agency, Taiwan, indicated that the motorcycle induced the highest accident rate, and drunk driving ranked first among the traffic fatality causes in 2007. The high traffic accident rate was attributed to the alcohol decaying driver reaction and the increase of frequency of using motorcycle in daily life as the car parking space and driving cost were considered. A motorcycle riding simulator, integrating a stationary real motorcycle and virtual reality system, was developed to measure motorcyclist brake reaction time under different drunken levels and braking procedures. The motorcyclist encountered an emergence that a pedestrian went across the road abruptly in a simulated driving scene. The time between an emergence and the activation of brake lever was recorded as the brake reaction time. Ten young participants, ranging from 20 to 25 years of age, were recruited in this study. Drunken levels for motorcyclist were designed to breath alcohol concentrations (BrAC) of none, 0.15 mg/l and 0.25 mg/l. In addition, two different braking procedures, subject positioned his fingers on brake level or had his fingers wrapped around the handlebar, were tested. The experimental results showed that a longer brake reaction time was induced by the motorcyclist under higher BrAC. Additionally, the brake reaction time is also significantly influenced by braking procedure. The results in this study gave really useful information for driving education and skill in the field of motorcyclist driving safety. As the motorcycle riding simulator in this study did not involve a motion platform, participants cannot experience emergency motions induced from abrupt acceleration and braking. However, by using state-of-the-art computer graphic technologies the

simulator gave a real like scene of emergency traffic event.

Paper No. 09-0399-W

Evaluation Of Needs And Possibilities To Change The Requirements In The Regulations Regarding The Possibility Of Observing The Surroundings In The N1 Vehicles

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Abstract:
The lack of information from the surrounding of the vehicle is one of the reasons of collisions and accidents. There is a radical limitation of unobstructed observation of the whole area surrounding trucks of N1 category in comparison to the car of M1 category. Vehicles which have the same body and which are designed to transport people – M1 category or load – N1 category, they have different equipment, such as side glazing and back walls. Those who are driving these vehicles don't have comparable and identical visibility. Technical progress and development in the area of visual transfer devices helps to use them in the vehicles in order to improve the possibility of observing the surrounding of the vehicle. There is an important need to change the regulation as far as construction and vehicles equipment is concerned. The regulation should compel the vehicles manufacturers to ensure such construction of the vehicle that the driver will have a possibility of observing the surrounding of vehicle in the range of scope and placement visible area would be comparable to the car. Setting this kind of requirement will force the producers to ensure visibility from the trucks comparable to that of cars. This will help avoid collisions and accidents which are caused by the substantial limitation of the possibility to observe the surrounding of the vehicle. These facts speak for the necessity and need of changes to the regulations. This paper offers the change of the philosophy of the regulations requirements in the area of visibility. The novelty is the definition of the needs and possibilities of changes in the regulations concerning visual transfer for trucks. There is no reason to tolerate the worse visual transfer in the vehicles N1 category. It is possible and is imperative to introduce regulations which will obligate the vehicles manufacturers to equip trucks in such a way that the possibility of observing the surrounding will be the same as in the passenger car version.

Paper Number 09-0450-W

Initial Site Inspection Of Motorcycle Collisions With Roadside Objects In New Jersey

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Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Abstract:
This paper details the methods used to investigate motorcycle collisions with roadside objects and the initial findings of the study. One factor associated with the frequency and severity of motorcycle collisions with roadside objects may be the design and maintenance of the road. Two methods of analysis were used to investigate the influence of the road geometry and design of roadside environment on motorcycle collisions. Satellite imagery was used to develop an overview of different collision sites. Individual site visits for 34 motorcycle-roadside object crashes were conducted to record details about each site, including types of guardrails and distance of the object struck from the road.

Paper Number 09-0458-W

Modification Of A Truck Front For Improved Kinematics In Run Over Accidents

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Abstract:
A major problem of the predominantly flat fronts of trucks used in Europe with respect to accidents involving vulnerable road users are the kinematics of the vulnerable road user after the impact. Contrary to car versus vulnerable road user accidents the flat truck front pushes the vulnerable road user to the road rather than lifting him. This effect causes a high risk of a run over.
The main idea of the presented safety device is to change the flat front to a tapered shape deflecting the vulnerable road user sideways by using the impact impulse. The achieved deflection reduces the risk of a run over. The tapered truck front has been designed and analysed within the EC funded APROSYS integrated project.
For a principal investigation the tapered shape is realised by an add-on structure mountable to the front of a reference truck. Hence, a direct comparison of the flat and the tapered shape is possible. Regarding a practically relevant application of this safety concept with respect to technical and economical feasibility the tapered shape has to be implemented directly in the cabin design. During the development phase of the new front structure a large number of design versions are generated and assessed. The resulting final principal shape is compared to the basis truck in various numerical simulations with different accident scenarios, pedestrian models and parameter settings.
Due to these results it can be concluded that a convex truck front significantly reduces the risk of a run over. It is most effective in accidents with higher speed (> 20 km/h) and the additional deformation space allows to reduce the contact forces at the primary impact. In this regard it has to be discussed whether the implementation of passive safety devices in trucks should implicate a revision of the vehicle length regulation.

Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Paper Number 09-0460-W

Evaluating Crash Avoidance Countermeasures Using Data From FMCSA/NHTSA's Large Truck Crash CaUnited Statestion Study

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Abstract:
Real world crash data are used to estimate the size of crash populations addressable by crash avoidance countermeasures. Until the release of the data from the Large Truck Crash CaUnited Statestion Study (LTCCS) that was conducted from 2001 to 2003 by the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA), only coarse estimates of those target populations were possible using data from the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System's General Estimates System (NASS GES). Both of these databases contain limited information that is coded from police reported data.
The LTCCS conducted on-scene investigations of real world crashes that resulted in a database of 1070 cases rich in detail, specifically related to precrash conditions and factors associated to why the crash occurred. The detail in the data was enough to make clinical (case by case) estimations of the applicability of crash avoidance countermeasures for each crash, based on our knowledge of these systems and how effective they are in certain scenarios. Final benefit estimates would take into account the applicable target populations and the effectiveness of a system, as determined through field operational tests or some other measure.
This study presents the results of clinical reviews of truck crashes from the LTCCS to determine which target populations of crashes could be candidates for prevention given the multiple factors that came into play. Countermeasures related to the truck, truck driver, or trucking industry might have prevented 61 percent of the crashes in LTCCS, including 50 percent that might have been prevented by advanced technologies that are currently available for trucks. The newly coded data from these clinical reviews can be used to further refine the applicable crash populations estimated from FARS and GES. This research indicates that only a portion of applicable crash scenarios identified through FARS and the NASS GES are candidates for prevention by crash avoidance countermeasures.
The results present an option for a more accurate methodology for estimating the size of crash populations addressable by crash avoidance countermeasures. Using these results it is possible to prioritize research on crash avoidance countermeasures.

Paper Number 09-0465-W

Development Of A Thorax Protector For Motorcyclists

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Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

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Abstract:
This paper describes the development of a new thorax protector as part of the personal protective equipment for motorcyclists. The function of the protector is the mitigation of injuries in impacts to the frontal or lateral parts of the thorax. A sandwich structure was selected. The outer shell of polypropylene was designed to spread concentrated impact forces, a shock absorbing aluminium honeycomb material was coupled with a comfort layer for the inner part of the protector.
The materials were characterized and an FE model was created for impact simulations with the HUMOS2 model. Frontal and lateral impact tests against which the HUMOS2 model had previously been validated were simulated. The simulations highlighted that the main benefit of such a device is derived from the force distribution and that the shock absorbing material provides smaller contribution to the protector's performance.
After a pre-selection of the design variants by means of simulation, a series of thorax protector prototypes were manufactured and tested in terms of comfort (ergonomic tests) and impact protection. Ergonomic tests confirmed the quality of the design, showing that the protector does not interfere with the normal rider's movements. A series of frontal impact tests using the Hybrid III Dummy was carried out. It was concluded that the protector reduces the compression of the thorax and the probability of sustaining rib fractures in the analysed impact conditions and thus reduces the potential injury risk.

Paper Number 09-0472-W

Method Of Driving Assistance System Design To Improve Human-Vehicle Interactions And Safety Technologies Developments For Trucks

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Abstract:
This paper presents a method to develop coherently a Driving Assistance System (DAS) and its supporting technologies in order to reach efficiently the best added value in terms of Human-Vehicle interactions and technology specification.
This method is an iterative development process based on a Human Centred Design approach. It requires a driving simulator and a development framework in order to simulate technologies. The first step of the method is to validate the DAS prototype through 3 iterative tasks: Study of the drivers needs, Design of the DAS with "perfect" technologies, Evaluation of driver-vehicle interactions to validate the effectiveness of the assistance. Then the second step is to obtain the

best trade off between effectiveness of the assistance and technological requirements through 2 iterative tasks: Modification of the technology performance by changing the specifications (toward existing, emerging or futuristic technologies), Evaluation of driver- vehicle interactions to validate that the assistance is still effective. This guides the final decision for the DAS production: use existing technologies, or develop better safety technologies.
This method is developed inside VIVRE 2 project, which aims to design an innovative DAS to help truck drivers engaged in low speed manoeuvres in urban areas. We first developed a prototyping platform, which we then used along with the method to design the DAS and to determine the best compromise in terms of Human-Vehicle interactions and technology specification. Even if the method inherits of the limitations of simulated environments, it permits a "driver in the loop" development of innovative DAS which would be difficult otherwise. Instead of using the classical approach "From technologies, to DAS design, to DAS evaluation", this approach shift the problem to "From driver needs, to DAS evaluation, to technologies".

Paper Number 09-0500-W

Design Of The Decision Logic For A PTW Integrated Safety System

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Abstract:
The Powered Two Wheeler Integrated Safety (PISa) project is developing an integrated safety system for a range of powered two wheelers (PTWs). This system includes state of the art sensors, innovative warning devices and rider assistance systems. This paper reports on the design of the decision logic for deploying autonomous braking (AB) and enhanced braking (EB) safety functions in the PISa system, for a PTW travelling towards leading obstacle, using on-board inertial measurement unit (IMU) and Laserscanner. The decision logic deploys the AB and EB systems based on a theoretical kinematic parameter: the required deceleration to avoid a collision. The criterion for deployment is to trigger the AB and EB systems when the collision is physically unavoidable. The decision logic is tested off-line for datasets acquired using the PTW integrated with the IMU and the Laserscanner.

Paper No. 09-0551-W

Testing Of Heavy Truck Tire Pressure Monitoring Systems (TPMS) In Order To Define An Acceptance Test Procedure

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Technical Session
Advances in Truck Safety/Bus & Two Wheeled Vehicles Safety

Abstract:
Several manufacturers produce tire pressure monitoring systems for heavy trucks which are designed to detect low tire pressure and alert the driver. This paper reports on a series of test procedures conducted on these aftermarket TPMS to determine the suitability of these tests for use in developing performance requirements.

Five TPMS were installed one at a time on two heavy trucks. The minimum activation pressure of the TPMS was determined. After driving for a period of up to fifteen minutes, the vehicle was stopped and air was released from one tire to bring its inflation pressure to a point below the minimum activation pressure for the system. The vehicle was driven and the time needed for the system to detect the loss of pressure and alert the driver was recorded. Multiple tire deflations and failure modes were also tested.

Data were obtained from independent onboard instrumentation that measured tire pressure, vehicle speed and distance, and ambient temperature. A video of the TPMS driver display was recorded. Other properties were also evaluated, including temperature compensation accuracy of system pressure measurement and failure modes. The study's results are limited to the five systems tested. Although these systems were chosen to be representative of TPMS on the market, this was not an exhaustive study of all such systems.