EUROPEAN ENHANCED VEHICLE-SAFETY COMMITTEE (EEVC) – THE RESULTS OF 42 YEARS OF ACTIVITY

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Abstract

Road safety was and still is one of the real hazards for human society all over the world. In order to manage the problem of excessive road death toll at the both sides of Atlantic two independent initiatives were started in 1970 in the USA in the US Department of Transportation. The paper describes the genesis of intergovernmental European initiative named EEVC, its history, participants and scope of former and current scientific research related to improvements in vehicle design safety. The work was started from the careful analysis of accident statistics data including the severity of accident. The important feature of EEVC working groups is participation of car industry researchers enabling wide verification of scientific achievements. For specific items, it is also shown the practical profit based on knowledge coming from EEVC research. Most important items resolved by EEVC were in-depth study of multidirectional impact mechanics, development of anthropometric dummies, pedestrian safety, passive/active safety interaction, rear under run protection etc. The influence of change in vehicle design appears important for all road users the vulnerable persons including. The relation to other similar international initiatives was pointed together with the future direction of activity and relation to National and International (UN ECE and EC) legislative bodies. The Polish input to EEVC research was described since in 2002 Poland started its participation.

Keywords: *road transport, vehicle design, passive and active safety, research, international cooperation*

1. Introduction

The European Experimental Vehicles Committee (EEVC) was founded in October 1970 as a European response to the US Department of Transportation's initiative for an international programme an Experimental Safety Vehicles (ESVs). Its scope was "to ensure the continuing exchange of information between the participating governments, and their collaboration to achieve the best use of their available resources in response to the United States' invitation to participate in the development of experimental safety vehicles". The ESV programme is no longer focused on the specific development of experimental vehicles but on the broader field of improving the safety of vehicles on the road, as indicated by the change of name to Enhanced Safety Vehicle. Nevertheless, the general objectives and tasks of the EEVC remain much the same today. EEVC changed its name to European Enhanced Vehicle-Safety Committee in 1997. The governments of France, Germany, Italy, the Netherlands, Spain, Sweden, the United Kingdom and Poland are members of EEVC. The EEVC has the full support of participating governments and their industries, and is able to draw on the best available expertise in all the safety fields considered. In addition to scientific and technical experts, the EEVC includes appropriate input from administrators and legislators. The reports of the EEVC are generally published in the proceedings of the ESV Conferences, and are also publicly available on the EEVC website. The EEVC provides the link between Government, Research and Development, Industry, Administration and Regulation in Europe in the quest for safer road vehicles.

EEVC has dealt with the following issues:

- Accident statistics,
- Human tolerance and biomechanics,

– Priorities for safer vehicles,
– Side impact protection,
– Pedestrian protection,
– Cycle and light powered two-wheeler accidents,
– Heavy goods vehicle safety,
– Motorcycle safety,
– Front impact protection,
– Impact dummies development,
– Compatibility,
– Child protection,
– Active/passive safety interaction,
– Rear impact protection.

This essential information can then be transmitted to the regulatory bodies, and to member governments, to take such action as seems most appropriate. It is important that the EEVC is able to pursue its work objectively and impartially, free from any sort of political pressure. Thus, the policy-based members are there merely to advise on relevance and application, and not to press national points of view. This mixture of expertise has worked very well in the past, and the conclusions of the various EEVC Working Groups have been based on an objective technical and scientific consensus, to provide an unbiased advice. The Steering Committee elects a chairman, a technical secretary and the chairpersons of the working groups. Presently, the Steering Committee is chaired by Dr. D. Cesari from INRETS (currently IFSTTAR). As the EEVC proposals must be fully practical, it is important that the knowledge and expertise of national representatives are complemented by those of the industry. For that purpose, experts from industry may be invited to attend working group meetings. These experts have observer status only, since it is essential to ensure that the research programme cannot be unduly influenced by the commercial concerns of industry. In practice, however, the work and the conclusions drawn are generally agreed by consensus and voting rights are rarely used. Similarly, in the interests of international harmonization, the Steering Committee may decide to invite observers from those other countries, which play important roles in international regulation or which can offer relevant information. This ensures that, wherever possible, the European vehicles research programmes are aware of developments in other countries, so that unnecessary duplication can be avoided. As noted below, an excellent degree of collaboration has been achieved. The working process of EEVC is based on terms of reference agreed by every country member. From the country point of view, the participation in EEVC works improves the access to EU framework programmes enabling better use of scientific and research base of the cooperating country.

2. Past activities of the EEVC

During the past years, the EEVC has contributed widely to the improvement of technical knowledge in the field of traffic accident analysis and measures to improve protection from injury through vehicle design. The first three Working Groups created at the time the EEVC was founded had the task of “making quick assessments of present knowledge of the accident situation and the prospects for safer cars”. Later Working Groups were set up to make longer and more detailed studies of those issues considered to be especially in need of research. The activities of each of these Working Groups are described briefly below.

Working Group 1: Accident Data

WG1 reviewed the sources of accident data available in Europe and commented on how these could best be developed to further the aims of car safety. This permitted the definition and classification of accident problems in order of importance. Recommendations for the improvement of accident studies were also made.

Fig. 1. The early version of Experimental Safety Vehicle – TRL

Fig. 2. The early anthropometric research dummy – INRETS

Working Group 2: Potential Safety Improvements

WG2 examined the information made available by WG1, and assessed realistic safety requirements, compared their priorities and identified scope for improvement.

Working Group 3: Human Tolerance Levels and Occupant Protection Evaluation Techniques

WG3 had the task of reviewing the technical problems involved in assessing occupant safety by impact test procedures. These studies included an assessment of currently available human injury tolerance limits, anthropomorphic dummies, and test techniques, together with recommendations for future research.

Working Group 4: Biomechanics

This Group extended the work of WG3 to identify the human tolerance parameters, which need to be considered in impact testing, gaps in current knowledge, and application to the development of better front and side impact protection.

Working Group 5: Impact Test Procedures

On the basis of the findings of WG3 and WG4, this Working Group identified the sort of test procedures which could be expected to produce an improved level of occupant protection, for both front and side impacts.

The final reports of WGs 1 to 5 allowed the EEVC to define, on the basis of European experience and technical knowledge, a sufficiently common view to provide an assessment of the future needs of car safety in Europe. Following this basic assessment, in the mid-1970s the EEVC turned its attention primarily to the fields of car occupant protection in side impact and to pedestrian protection by improved design of the fronts of cars.

Working Group 6: Structures for Improved Side Impact Protection in Europe

This Working Group expanded on studies of side impact done within WG5 to formulate a full-scale test procedure, in conjunction with an ad hoc group which was set up to consider the requirements for an anthropometric test dummy to indicate likely injury levels in a side impact.

Working Group 7: Pedestrian Injury Accidents

The importance of pedestrian injuries had already been identified in the work of WG1, and this Working Group further analyzed the available accident data to identify the most productive approaches to reduce this toll. An ad hoc group was constituted to consider the influence of car design and the types of injury caused to pedestrians.

Working Group 8: Cycle and Light-Powered Two-Wheeler Accidents

This study of two-wheelers was undertaken in parallel with the pedestrian studies of WG7 because of the prevalence of car/cycle collisions in the Netherlands especially. It examined the types of accident which occurred and reviewed the counter-measures which might be taken.

Working Group 9: Side Impact Test Procedure

This working group analyzed side impact accidents conditions to determine the test conditions of the proposed full-scale side impact test. Taking into account the characteristics of the cars on the roads in Europe, it has developed a deformable barrier to be used in revised European side impact Directive. It also proposed the use of the Eurosid dummy to assess the protection levels provided, and the relevant injury criteria to be used.

Working Group 10: Pedestrian Protection

This working group looked at accident data to prioritise injuries and the body segments to be protected. It has examined a large number of experimental impacts between whole cars, and car front sections on a test rig, and specially developed instrumented dummies to represent both adult pedestrians and children. Computer simulation using the MADYMO package has also been used to aid understanding of the mechanisms involved. It concluded that the protection of pedestrians hit by cars can be assessed by the use of subsystems tests.

Working Group 11: Frontal Impact Test Procedure

EEVC Working Group 11 on Frontal Impact Test Procedure completed a series of frontal impact tests in 1993, with the Support of the EC, to determine the conditions for an offset deformable barrier test. A proposal for a new frontal impact test procedure was presented at the 1994 ESV Conference. The Working Group then evaluated this proposal by testing a wide range of modern vehicle designs and types. The final report was produced in autumn 1995. The test procedure has already been accepted by the UN ECE WP.29. The European Commission has released a directive on frontal impact effective since October 1998.

Ad Hoc Group on Motorcycle Safety

The EEVC has set up an Ad Hoc Group a Motorcycle Safety to review all aspects of motorcycle safety connected with the design of the machine or the rider's clothing, but excluding matters of rider behaviour and training. The Group reported in 1993, with a review covering accident and injury data, braking and handling, visibility, passive safety, leg protection, airbags, trajectory control, helmets and clothing, and the road environment. It is clear that this transport mode carries a much higher risk of injury than does an enclosed four-wheeled vehicle, but the study identified a number of promising approaches which might reduce the risk of accident and provide better protection. A summary of the findings was presented at the 1994 ESV Conference.

3. Currently active Working Groups

The result of already described EEVC activity established the base for currently performed and planned research programmes (WG 12 to WG 22). It can be summarized as follows:

Working Group 12 and 13: Frontal Impact Dummy Development and Side Impact Protection

The work of EEVC on this issue was started in 1990 and focused on the following items:

- Frontal impact dummy,
- EUROSID 2.

After some 10 years experience with research and regulatory testing using EuroSID-1, it was apparent that some aspects of its performance could be improved. It was therefore agreed that EEVC Working Group 12 would monitor and review design improvements being undertaken by the dummy manufacturers and also by WG12 members under the auspices of the EU programmes SID2000 and SIBER. In addition, under a Letter of Agreement with NHTSA, the concerns expressed by NHTSA regarding some aspects of the performance of EuroSID-1 used in the safety standard FMVSS 214 test procedure, were also taken into consideration. NHTSA undertook to review the revised design as a possible candidate dummy for use in FMVSS 214. The revised design has been designated EuroSID-2 or ES-2 and, following a review of the extensive evaluation of this design, the EEVC has recommended its adoption in side impact testing in place of EuroSID-1. (EuroNCAP use ES-2 from 2003).

Fig. 3. Motorcycle equipped with airbag and leg protectors crash test – IMMA

Fig. 4. Test dummy WorldSID – the 5 percentile woman – INRETS

Working Group 14: Energy Absorbing Truck Front Underrun

Due to the lack of financial support, the work of Working Group 14 has been delayed and had finally started in Summer 2002. Based on the earlier work of WG14, the EC 5th framework project VC-COMPAT was carried out over a period of 3 years. Most former members of WG14 and additionally some truck manufacturers were members of the VCCOMPAT consortium. The main project outputs with respect to car to truck compatibility were:

– test procedures and associated performance criteria to assess and control truck frontal structures for frontal impact compatibility with cars,
– suggestions for improving rear and side under run safety,
– indication of the benefits and costs of improved compatibility.

Fig. 5. Front under run crash test – INRETS

Working Group 15: Improvement of Crash Compatibility between Cars

In February 1996, the EEVC Working Group Improvement of Crash Compatibility Between Cars was established. Compatibility considers collision partner protection as well as self-protection in order to minimize overall injury risk. The task of the group was to identify compatibility problems, determine the parameters which affect compatibility, identify potential benefits from improvements to compatibility and develop test methods and criteria for assessing compatibility. Co-operative research work started in July 1997 with a two-year project partly funded by the EC. The goal of the project was to start a scientific approach to the understanding of compatibility. Initial effort was concentrated on the most important impact types: car-to-car frontal and side impacts. The work covered three main activities:

– data from in-depth accident studies were used to identify the most important problems related to compatibility,
– typical accident configurations were replicated by carrying out experimental car-to-car impacts. These crash tests helped to identify the major problems occurring when two cars collide,

– computer simulation modelling was used to study the sensitivity of main parameters such as stiffness and mass.

From the research activities, WG 15 derived the following principles for frontal impact compatibility:

– good structural interaction,
– control the strength of the passenger compartment to avoid collapse,
– match frontal stiffness to manage vehicle deceleration,
– provide predictable crash performance in a range of impact configurations,
– in setting the requirements, consider the future capabilities of advanced restraints while respecting the limitations of current restraint systems.

Although less is known about side impact compatibility, the following aspects are currently considered to be the most important:

– geometry has a large effect,
– mass and stiffness have smaller effects (frontal stiffness distribution of the bullet vehicle may be only relevant for about the first 100 mm),
– vertical intrusion profile to distribute loads on the occupant,
– sill engagement.

It was determined that, for car to car frontal impacts, the structural interaction between the two cars, the stiffness of the car front end and the strength of the passenger compartment are the first factors that should be studied to help in the assessment of compatibility.

Working Group 16: Advanced Offset Frontal Crash Protection

The EEVC Working Group Advanced Frontal Protection WG16 was formed in 1997 primarily to support the EC in the evaluation of the Frontal Impact Directive. Support to the IHRA has also been a major responsibility for the working group. The major part of the evaluation of the Frontal Protection Directive was submitted to the EC in January 2000. Some additional facts concerning important barrier criteria were reported to the EC in February 2002. The latter report explores some of the reasons behind the design of the offset deformable barrier being proposed for the directive. A good understanding of the reasoning and compromises leading to the existing design is essential. The working group is well underway with developing a method for measuring footwell intrusion. The method is aimed at measuring intrusion relative to a normal foot position. There are links between primary protection, as explored in this working group, and secondary protection as discussed in the Crash Compatibility Group. As a result of this, the IHRA has merged the Frontal Protection Group with the Compatibility Group. The more holistic approach to crash safety gives good possibilities for the development of test methods which support one another minimising, or at least understanding potentially conflicting goals. Support to the IHRA is given by the Frontal Protection Group together with the Crash Compatibility Group. Modern cars, to a very high degree, depend on the use of seat belts to give maximum protection. But seat belt use in crashes is still very low. The working group has developed recommendations for technical systems to support the use of seat belts. A report has been submitted to the EC and the ECE exploring the potential design of seat belt reminder systems.

Fig. 6. Frontal impact against OBD – TNO

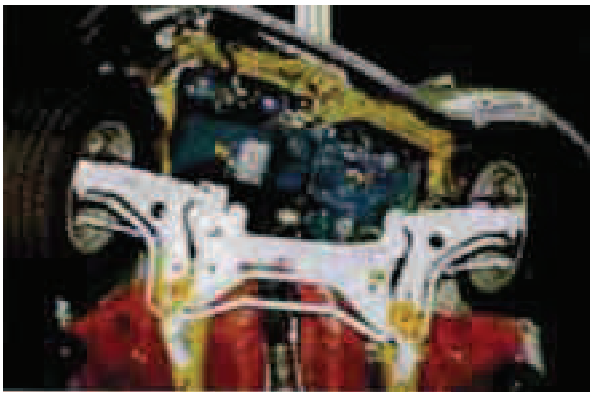

Fig. 7. Vehicle underbody after frontal impact against OBD – BASt

Working Group 17: Pedestrian Safety

Pedestrian casualty numbers contain a disproportionately large number of elderly people and children, but pedestrians of any age are obviously very vulnerable when struck by a vehicle. Since it is not possible to provide the pedestrian directly with any useful protection, it might be thought that little could be done to reduce these casualties, and there is certainly little chance of avoiding serious injury or death in a high-speed collision. But 80 per cent of all car/pedestrian collisions, and 25 per cent of fatalities, occur at impact speeds of 40 kph or less. At these lower speeds, there is much which can be done to make the front of a car less injurious. The EEVC set up Working Group 10 on Pedestrian Protection in 1988 to examine this problem and to develop a test procedure to assess the injury potential associated with any given car model. This work was requested and funding provided by the European Commission for consideration as an EU Directive. Again, the work has been a fully collaborative research exercise between APR, BASt, INRETS, TNO and TRL. Pedestrian injuries are most frequently to the legs, pelvis and head. The car bumper strikes the lower legs or knees, the bonnet leading edge strikes the upper legs or pelvis, or, in the case of children, the abdomen. The head of the pedestrian tends to swing down onto the bonnet top, the wings, or further back onto the scuttle or windscreen in the case of taller pedestrians, shorter bonnet or higher impact speeds. The EEVC Working Group has examined a large number of experimental impacts between whole cars, and car front sections on a test rig, and specially developed instrumented dummies to represent both adult and children. Computer simulation using the MADYMO package has also been used to aid understanding of the mechanisms involved. To minimise injury, particularly to the knee joint, the bumper should spread the load of the initial contact along the length of the lower leg, avoiding any concentration on the knees, and its surface should deform to reduce the load. A deep bumper will accelerate the pedestrian’s leg and cause it to break contact with the ground. MADYMO Modelling Car to Pedestrian Impact The bonnet leading edge, and as far as possible the tops of the wings and the corners of the car, needs to be deformable, to crumple and so absorb energy without retaining strong, solid parts such as bonnet latches close to the edge. Depending on the height of the pedestrian, speed of impact and bonnet length, the head may strike the bonnet top. The head injuries this causes can often be fatal, and to minimise the risk of this the bonnet should be designed to collapse in a controlled way, absorbing energy and without the many hard components in the engine compartment lying so high that they prevent the required amount of collapse. To avoid the expense and complexity of a full-scale impact test, and to provide a better repeatability, the EEVC Working Group has developed a test of each of these three sub-systems: the bumper assembly, the bonnet leading edge and the bonnet top. These are struck by impactors designed to assess the protection afforded to, respectively, the legs, pelvis, and head of both child and adult pedestrians. The tests aim to ensure that the car front will minimise injuries, but without dictating styling. However, since the shape of the front determines the pedestrian's trajectory, the required impact speeds for the test impactors are determined by the geometry of the cars in question. The test procedure

Fig. 8. The visualization of pedestrian/vehicle accident from 40 kph using MADYMO

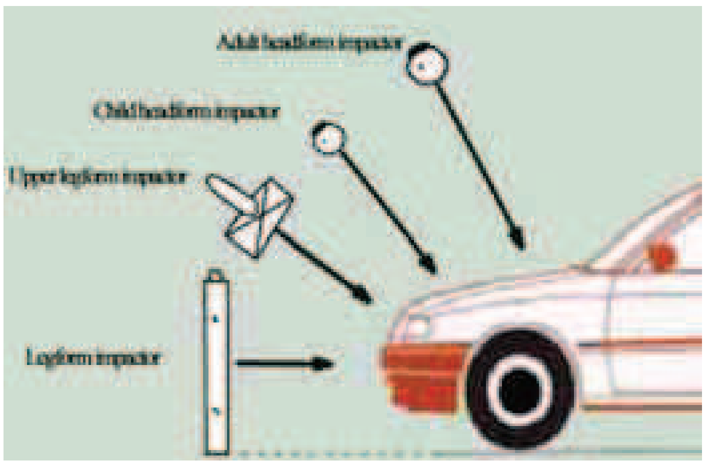

Fig. 9. Pedestrian crash test method developed by EEVC

developed was submitted to the European Commission and these sub-system tests are already being used to help in the design of future, more pedestrian-friendly car models. EEVC Pedestrian Protection Test. At higher speeds, the heads of pedestrians are likely to be seriously injured by the hard structure surrounding the windscreen, and attention needs to be paid to this. But the improvements in car front and bonnet top which will be required by the EEVC test procedures will achieve a substantial reduction in pedestrian injury. The EEVC Working Group estimates that they are likely to reduce pedestrian fatalities by 6 to 10 percent and serious injuries by up to 30 percent. After more than three years of experience of subsystem tests, the report "Improved test methods to evaluate pedestrian protection afforded by passenger car", originally published in December 1998, has been recently updated.

Working Group 18: Child Occupant Safety

A working group on car child occupant safety was created in October 2000, with the following terms of reference:

– review accident statistics with respect to car child occupant accidents and injuries in all types of car accidents,
– review research with respect to car child occupant safety,
– describe the state of the art taking into account all relevant regulations,
– identify lacks in knowledge, methods and tools,
– child protection in buses and coaches.

It was decided to hold hearings of different representatives from working groups concerned with child protection. The aim is to review pending research programmes, to gather the results and to study the improvements that these programmes could brig to the area of regulation. A comparative analysis of the different regulations used in Europe will be made. The work will be focussed on the European legislation, and, although the context is different, it will examine recent decisions on regulations in the US, Australia, Canada. The basis of this work is an existing document from ISO TC22/SC12/WG1.

Ways to progress:

– the major way of reducing the number of children killed or severely injured is to have them restrained and encourage police forces to enforce regulations,
– to reduce misuse (incorrect use of a CRS) should be another significant step for child safety. Studies on the real situation and the effects of misuse in accidents are necessary to quantify the possible gain,
– information on child safety could be given to children, parents, teachers, etc., and the risk of injury has to be stressed,
– research work on the biomechanics of children still needs to be conducted,
– to improve the protection offered by restraint systems, test methods and regulation revisions should be based on injury criteria.5

The focus of the EEVC work in this field is on the new generation of European child dummies: the Q dummies. From a study completed in 2008 it was concluded that the Q dummies offer a major step forward compared to the current P dummies used in UN Regulation No. 44. Currently the following 5 dummies are available in the Q family: a new born a 9 month, a 1.5 year, a 3 year and a 6 year old dummy. The development of a 10 year old version of the Q dummies is taking place in the European project EPOCH [5]. The dummy is expected to be completed in 2012. WG 12 monitors these developments and plans to deliver a status report after completion of this dummy in 2012.

Working Group 19: Active-Passive Interaction

Due to modern technology developments, there is an influence of active safety measures on passive safety of vehicles. Therefore, the EEVC has recently created a new working group with the following terms of reference:

– overview of existing and future techniques and how this is coordinated by existing organisations,
– effect of these techniques on priorities for injury prevention,
– effect of these techniques on existing regulations.

The first report of this group was delivered in 2004 and final was concluded in 2010 (the Polish representative was participated in the group). Currently the group concentrates his activity on advanced driver support active systems.

Working Group 20: Whiplash

Based on the work of an ad hoc group on whiplash injuries, the EEVC set up a working group on rear impact protection with the tasks of developing and validating test procedures, defining test devices and setting associated performance criteria. The first report of the EEVC whiplash working group was delivered after completion in 2008 of an extensive evaluation of various crash dummies for low-speed rear impact, from which it was concluded that the BIORID is the most suitable dummy for this type of accident, WG 20 has focused its activities on seat performance criteria (whiplash criteria). In Dec. 2010, an interim report on the analyses of real world (insurance) data was finalized. The main finding of this preliminary study was that the neck injury criterion NIC and upper neck shear force seem to be the best predictors for short and long term neck complaints following a rear-end impact. The work on this topic will continue in 2011 using a larger insurance database and new seat tests with the BIORID dummy in order to verify and further elaborate on these initial findings.

Working Group 21: Accident Statistics

The group was re-established for preparation of accident investigation protocols which fits better the interest of other active EEVC working group. On the base of group recommendation the latest statistics in scope of pedestrian accidents and accidents with children transported in buses were collected (the Polish representative was participated in the group).

Working Group 22: Virtual Safety

Group was active since 2004 and prepared basis for evaluation methods of virtual testing (the Polish representative was participated in the group). Currently new ToR (terms of reference) are under preparation in the direction to use as well simplified as advanced (considered vehicle and human body dynamics) programs and material science in accident analysis.

New informal group on bus frontal crash

Group was active since 2009 but after 2 years of work the new international project SAFeBUS for solving the item was started and the motivation for group was no longer in case.

4. Future of EEVC and conclusion

EEVC, from the beginning; is convinced that pre-regulatory safety vehicle research has to be approached at world-wide level; within that objective the Steering Committee of EEVC has confirmed that non-EEVC countries can participate at WG level to share their research. EEVC has existed for more than 40 years, and during this period, the environment of pre-regulatory research in the field of vehicle safety in Europe (and world-wide) has considerably evolved. EEVC's Steering Committee has decided to launch an internal reflection on its future, with the challenge to understand better the new world in which we have to work and to determine our future research directions and priorities. The discussion will consider the links with WP.29 (UN ECE World Forum for Harmonisation of Vehicle Regulations), in order to take into account the agenda of WP.29/GRSP (and other GRs dealing with vehicle safety) in EEVC priorities and to find the most efficient manner to report EEVC work to these bodies. The links with the European Commission will also be addressed in the discussions, especially the relations with DG Entreprise (in charge of regulatory aspects) and DG Research. The planned discussions will also review the questions related to the status of EEVC, the procedures for financing researches prioritized by EEVC as well as the involvement of new countries in EEVC activities. EEVC's Steering Committee has decided that the setting of the research agenda is the critical parameter in the further work of the EEVC, for both the scope of its activities and its priorities. It was agreed that short term and longer term research needed to be considered together. For that purpose, the EEVC Steering Committee has planned to meet in 2012.

The passive safety testing procedures developed by EEVC are used in EuroNCAP evaluation and will soon be supplemented by active safety testing related to HMI (Human Machine Interaction) driver support systems.

Motor Transport Institute (ITS) participates in EEVC works since 2002 (activity in WG19, WG 21 and Informal Group on Bus Frontal Crash) and intends to continue this cooperation for the reason of having the opportunity to get the latest world knowledge related to vehicle safety.

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