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EARPA Position Paper

FURTHER ADVANCES IN AUTOMOTIVE SAFETY IMPORTANCE FOR EUROPEAN ROAD TRANSPORT RESEARCH

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THE EARPA TASK FORCE SAFETY

Founded in 2002, EARPA is the association of automotive R&D organisations. It brings together the most prominent independent R&D providers in the automotive sector throughout Europe. At present, its membership counts 33 members ranging from large and small commercial organisations to national institutes and universities.

The Task Force Safety was formed in 2005 in order to discuss safety research topics of common interest and develop common positions on the importance of European automotive safety research integrating the key elements of the road transport system - the vehicle, the infrastructure and the user. It brings together 18 members of EARPA, with expertise in all major fields of this research domain from primary to tertiary safety[1]. This position paper presents a synthesis of the Task Force members' view on the relevance of RTD on automotive safety, a vision on future safety & mobility and suggestions of future safety research priorities.

RELEVANCE AND IMPORTANCE OF RTD ON AUTOMOTIVE SAFETY

Although important improvements in road traffic safety have been achieved during the last years, still an average of more than 100 people die on European roads each day and many more get severely injured. This situation is unacceptable both from an ethical perspective and from an economic point of view. The WHO with reference to the European Transport Safety Council estimates that the economic loss from road traffic injuries accounts for about 2% of gross domestic product in the EU[2], while the human suffering in terms of physical and psychological consequences of death, injury and disability is hard to quantify.

In its Transport White Paper adopted in 2001, the European Commission set the ambitious target of halving the number of fatalities on European roads by 2010. In spite of all progress, accident statistics reveal that most probably this target will not be met. Therefore, it is obvious that even greater efforts are necessary in order to reduce the number of fatalities and the severity of injuries caused by road accidents more rapidly. At the same time, the growing interest in a new generation of green, sub-compact cars, the introduction of alternatively powered vehicles and the electrification of drive trains in particular will pose new challenges to road safety. Smart solutions are necessary to enable lightweight vehicles with reduced carbon footprint and improved safety.

The progress in the reduction of road fatalities achieved so far is to a large extent due to intensive R&D work by the European automotive industry and its partners. This has put the European industry in a leading role in automotive safety, which should be maintained as a competitive advantage. Further significant advances require actions by all stakeholders from the industry and the infrastructure providers to legal bodies and the RTD community. In this multi-stakeholder approach, all phases from primary to tertiary safety have to be taken into account in a holistic concept of automotive safety.

FUTURE SAFETY & MOBILITY

Taking into account the importance of improved traffic safety as well as the challenges resulting from the limitation of fossil fuels, the need for CO_2 emission reduction, the ageing European population, global competition and the growing demand for mobility worldwide, EARPA members have developed a vision on future safety and mobility, which is articulated in the long-term objective of realising both **Vision Zero** and **Efficient Mobility** for all sections of the population. Committing to the Vision Zero concept means striving for a road transport system in which no-one is killed or severely injured anymore, and that human life is the paramount concern, which cannot be traded off for other benefits. However, mobility should still be efficient,

[1] CEA, CIDAUT, CTC, FhG, IDIADA, IDMEC, ika, K.U. Leuven, LMS, OTAM, Ricardo, SAFER, SP, Tecnalia, TNO, TU Graz, UNIFI, VTT

[2] Preventing road traffic injury: a public health perspective for Europe, World Health Organization, 2004

which implies fast, reliable, convenient and affordable transport of persons and goods with minimum use of resources and minimum pollutant, noise as well as greenhouse gas emissions. This is in line with the European Transport Safety Council's call for simultaneous mobility and safety becoming a fundamental right of every EU citizen[3].

Realising a future road transport system which complies with this vision of EARPA will require an integrated approach including the infrastructure, the vehicle and the user. This is reflected by the characteristics of the future road transport system envisioned by EARPA partners:

The system should be based on an intelligent, forgiving infrastructure, which might need to provide a better separation of different kinds of vehicles / road users. It should include new vehicle types with innovative propulsion systems and adapted structural design. Important attributes of such vehicles are lightweight design, compatibility, also with regard to conventional vehicles, and a high degree of intelligence. "Intelligence" in this context implies that vehicles should be able to communicate with each other as well as with the infrastructure, while communication with the driver should be situation- and user-adaptive to a great extent. In co-operation with intelligent infrastructure, intelligent vehicles should sense their environment, detect possible hazards, react accordingly and finally enable autonomous driving, at least as an option on dedicated roads. Moreover, different vehicle types should be available to citizens for different transport tasks (commutation to and from work versus holiday trips) and for the different needs resulting from human diversity.

However, Vision Zero and Efficient Mobility will only become a reality, if this concept of the future road transport system is supported by appropriate user behaviour. While the fact that humans make mistakes has to be accepted, regulations and incentives should encourage responsible and reflected behaviour of all road users. Where necessary, strict enforcement of traffic rules should be applied by automated processes. Moreover, road traffic is not a closed system. Smart planning services taking into account all transport modes should optimise modal split and facilitate smart combinations of different modes. Co-modality should also enable the avoidance of motor-vehicle traffic in sensitive areas such as city centres. Finally, it is important to accept that even in this ambitious scenario accidents will happen on European roads. Vision Zero can still be realised, if sufficient protection is provided to <u>all</u> road users including the most vulnerable ones in <u>all</u> accident scenarios.

Since road traffic safety is a global issue, many characteristics of the future European road transport system envisioned by EARPA partners might be considered a desirable scenario in other parts of the world, as well. EARPA experts are fully aware though that the enormous road safety problems which many emerging economies are facing might require specific short- to medium-term actions, which may differ from those intended to further improve the situation in Europe.

AUTOMOTIVE SAFETY RESEARCH PRIORITIES

Based on their vision on future safety and mobility described above, EARPA experts have agreed on a number of priorities in the field of automotive safety research which will pave the way for the realisation of this vision in Europe and contribute to its realisation also in other parts of the world. The starting point of the discussion, which was open also to external experts, was the Secondary Safety Research Action Plan (SSRAP) issued by the Advanced Passive Safety Network (APSN) in 2007. This document represented the views of a wide range of actors including OEMs, suppliers, research organisations and universities. The independent research providers' experts reviewed the research issues from the SSRAP in 2008, completed them by new issues from the entire field of automotive safety and finally prioritised the different topics. A regular updating process was initiated in 2009 with another workshop on future safety research needs and a subsequent survey among European automotive safety experts. Grouped into four safety research areas, 16 topics of major importance have been identified, which are described in the following.

While these are topics of research, EARPA experts acknowledge that research findings have to be implemented and new technologies to be adopted by the market in order to result in real safety benefits. Regulations and consumer testing have proven to be important drivers in this process. Cost-benefit analyses should help to prioritise different options for action when preparing new regulations or establishing new consumer tests. Moreover, it is important to note that all automotive safety research should be based on the findings of accidentology helping to identify and quantify the root causes of hazards.

[3] Road Safety as a right and responsibility for all, European Transport Safety Council, 2008

Research Area 1 "Intelligent Safety"

- **Intelligent Integrated Sensing Systems**

  Sensors and sensing systems are a critical aspect of advanced control systems including Advanced Driver Assistance Systems (ADAS). These include both on-vehicle sensing systems (such as lane detection systems) as well as off vehicle sensor systems (such as GNSS). The development of new sensor systems and the integration of sensors (e.g. through sensor fusion) offers a significant opportunity in the provision of advanced safety features. In addition, there needs to be a clear understanding as to how new sensors and sensor data can be readily integrated into existing vehicle systems to provide either increased safety, increased reliability or reduced cost. There are also significant opportunities to reduce sensor cost through new sensors and sensor fusion. This area is particularly important as automotive systems evolve towards fully autonomous vehicles.

- **Intelligent Vehicle Dynamics**

  New vehicle concepts with alternative propulsion systems will open new opportunities for smart vehicle dynamics control systems. Research should be done to exploit, for example, the full potential of the adaptive control of electric motors on wheel-hub motor driven vehicles to influence lateral and longitudinal dynamics and further improve primary safety. The integration with existing driving dynamics systems has to be taken into account.

  The minimisation of accident risks by the situation-specific active intervention of autonomous safety systems into driving dynamics control is an important objective both for alternatively powered vehicles and for conventional ones. Further research is needed on technical as well as on socio-economic and legal issues in order to enable the extensive implementation of such systems into the fleet, which will probably require not only a braking, but also a steering function for optimum effectiveness. Such research should be targeted to applications in different kinds of motor-vehicles including heavy trucks and vehicle combinations.

- **Integrated Traffic Applications**

  The possibilities to enhance road safety through V2X communication should be further explored in all phases from primary to tertiary safety. This includes the definition of vehicle requirements and system standards. A focus should be on infrastructure technologies, which can provide the vehicle respectively the driver with safety-relevant information on the current status of the road infrastructure and the traffic situation. Cost-benefit analyses of communication-based safety systems should be developed, as well. Moreover, the consideration of security issues will be indispensible to prevent reliably the abuse of communication channels for criminal purposes.

- **Advanced Controls as Evolutionary Step towards Autonomous Driving**

  While it is clear that the vast majority of accidents are due to driver errors, the complexity of traffic scenarios makes impossible, in the short-to-medium term, the introduction of fully autonomous driving systems in the normal traffic. Research has to pursue this final target of autonomous driving using an evolutionary approach, trying to support more and more the driver in his/her task but not substituting him/her completely. This shared control depends on the traffic scenario complexity and driver preferences, but always improving the overall safety level. In the medium term some driving tasks could become automatically performed under the driver supervision, like driving in a queue, opening the future possibility to fully automatic road traffic.

Research Area 2 "Structures & Materials"

- **Battery Safety**

  A major safety issue evolving from the electrification of drive trains is the behaviour of the respective energy storage systems in crash conditions. Research should focus on representative test and evaluation methods and performance criteria for electrical storage systems. This requires electrical, chemical and mechanical research including the high-voltage lines to the electric engine. All phases of an accident must be covered – from the pre-crash to the rescue phase – by virtual and experimental methods. In particular, representative experimental and virtual tests, performance criteria for electrical storage systems in crash conditions as well as guidelines for the integration into the vehicle are needed. Reliable modelling of the crash behaviour of electrical storage systems will be a prerequisite for this. Safe charging and discharging of the electric storage system including the design of the interface to the grid should be a topic of future safety research, as well.

- **Crashworthiness of Electrified Vehicles**

  The electrification of drive trains causes new challenges with regard to crashworthiness and, at the same time, offers new chances to improve the crash safety of vehicles. The bulky and heavy battery packs which vehicles will have to be equipped with in the coming years in order to offer a significant purely electric operating range will not only form a safety risk on their own when being damaged, but will also have a major influence on the full vehicle's crash deformation behaviour and on the resulting deceleration patterns. Electric motors with high voltage and hydrogen tanks for energy storage in fuel cell electric vehicles will introduce new risks which have to be tackled, too. On the other hand, new package concepts enabled by the replacement of mechanical shafts by electric power transmission and the introduction of wheel-hub motors in particular will facilitate radically new designs of crash structures and finally enable rethinking the vehicle architecture as a whole. In combination with the application of new materials, this will also be the basis for major advances in lightweight design allowing for the extension of purely electric operating ranges. Last but not least, the interaction of alternatively powered, lightweight vehicles with conventional ones in terms of crash compatibility should be a topic of future research.

  Research activities should cover the whole range from basic risk analyses to the development of design guidelines and test procedures which allow for a holistic safety assessment of electrified vehicles while limiting the risks immanent in the tests themselves. Links to other research activities in particular on the issues "battery safety" and "downsizing of vehicles" as well as on fire and electrical safety should be established in a coordinated approach.

- **Downsizing of Vehicles**

  Modern automotive regulations, global anti-pollution policies, management of resources and economical development will call for providing the user with a car which has a reduced size, which is ecologically friendly (emissions, material recycling, manufacturing processes), affordable and most of all safe. However, there is a conflict with current safety paradigms, according to which smaller vehicles have to be designed with stiffer structures, modifying the energy absorption characteristics and requiring more aggressive restraint systems. Research should therefore be targeted towards the amendment of safety requirements for the different types of vehicles available, based on an in-depth research on what are the optimal features a small car should provide compared to those of a larger vehicle.

- **Active Structures**

  Structures which actively adapt to different accident scenarios and user groups show the potential of real breakthroughs in the further improvement of road safety. Such structures might be able to redirect crash energy into unloaded areas of the vehicle body and help to generate optimal crash pulses. Self-adapting functions can be realised by the application of multifunctional, smart materials. Research is necessary on the development and optimisation of such materials as well as on the concept development and design of adaptive structures for safety applications. While reversible functions will offer benefits particularly in case of erroneous activation, improved sensor technology might give room for non-reversible systems, too.

Research Area 3 "Human Aspects"

- **Vulnerable Road Users**

  For many years, pedestrian safety has only been addressed through infrastructure measures. The pedestrian safety directive, which became effective in Europe in 2005 and was revised by the adoption of a Global Technical Regulation in 2009, as well as the inclusion of pedestrian protection in Euro NCAP have included passenger cars in the drive to reduce pedestrian casualties. Further improvements will require the inclusion of other vulnerable groups like cyclists and the consideration of new safety systems like pre-crash sensing to avoid collisions with vulnerable road users or mitigate the consequences of impacts.

  A specific research need in this context is the development of test methods for new technological solutions detecting pedestrians and two-wheelers as early as possible before the impact and opening the doors for the reduction of impact speeds and for the activation of deployable systems. Suitable assessment methods will also be required to encourage the widespread introduction of such systems.

Moreover, the existing head and upper leg impactors have not been improved since the early developments in EEVC WG 17. Further research is necessary on their dynamic responses and kinematic behaviour as well as on the application ranges of impactors (e.g. lower leg impactor for SUVs). The need of new test tools for deployable systems and for the representation of other vulnerable road users than pedestrians should also be explored.

Finally, current legislation excludes the A-pillar and windscreen frame, which are the most aggressive car features for a pedestrian's and cyclist's head due to conflicts with other requirements (roof strength, driver vision etc.). This issue should gain special attention.

- **Driver Monitoring**

  Since mistakes by the driver are a dominant factor in accident causation, driver monitoring should facilitate major improvements in road safety. Research should aim at possible ways to determine the condition of the driver, for example in terms of drowsiness, and finally result in systems which provide information about the degree of the driver's awareness of the current situation. Appropriate actions could then be taken via the human machine interface and/or by direct intervention of safety systems in vehicle dynamics. In parallel, socio-economic research should help to identify the best strategies to promote the implementation of driver monitoring functions and pave the way for their adoption in the fleet.

- **Adaptation to Different User Groups**

  The amount of information provided to the driver by comfort and safety systems is steadily increasing, which can cause distraction of the driver from the actual driving task. The amount of information which can be processed depends, however, on the type of driver and on the current condition of the driver. Therefore, the human machine interface (HMI), including the control elements, should become situation- and user-adaptive to a great extent. Research should analyse the needs of various user groups such as elderly drivers and address the question what HMI elements to adapt and how to adapt them in which situation.

  Apart from indicator and control elements, also restraint systems should be adaptable to provide optimum protection to occupants of all sizes, weights and constitutions including children and elderly people with their specific biomechanical characteristics. Research should contribute to a better understanding of these characteristics and to the development of self-adapting restraint functions.

- **HMI Assessment Methods**

  With HMI design becoming a more and more important aspect of vehicle engineering, new methods for the evaluation and assessment of HMI concepts (including driver monitoring functions) should be developed. Such methods should cover a broad range of issues like usability, usefulness and acceptance of different HMI concepts (tactile, acoustic, optic). The final outcome should be the definition of common evaluation and assessment methods accepted by all relevant stakeholders: from the design engineer to the user.

Research Area 4 "Assessment Methods"

- **Simulation Tools for Integrated Safety Systems**

  Safety systems shall offer protection in a wide variety of critical traffic situations. However, the number of scenarios which can be analysed in physical tests is limited by test costs and by possible safety risks – the latter in particular when it comes to systems acting in the immediate pre-crash and crash phase. Taking into account the characteristics of the vehicle, the user and the environment, simulation tools might enable a more exhaustive evaluation of integrated safety systems than physical tests. Research should be done amongst others on the further development of appropriate tools and on the specification of an extensive catalogue of use case scenarios, on the basis of which integrated safety systems could be evaluated virtually. In the end, a standardisation process could be initiated based on virtual testing.

- **Field Operational Tests**

  Field Operational Testing (FOT) is recognised as an effective instrument to test new transport technologies in the real world, and can help analysing and better understanding driver behaviour in driving tasks, providing information from the vehicle and from the driver both in safe and unsafe situations. More specifically, FOTs can be used to validate the effectiveness of ICT-based systems and functions for a safer, cleaner and more efficient transport. The aims are to analyse driver behaviour and acceptability, to analyse and assess the impacts using real-life data and to improve awareness about the potential of intelligent transport systems. FOTs are a powerful tool for gaining insight into the way new functions and systems suit the user when operated in the real context and for a sufficient long time to reach the daily operational and behavioural level. The first FOTs have been launched in Europe, but still most of the ICT-based systems and functions have not been considered yet. Additionally, as a preliminary result of the running FOTs, it becomes apparent that the derivation of impacts from recorded surrogate measures from the field needs more extensive research. So far no valid methodology exists to translate changes in driver behaviour and traffic situations in impacts on safety and efficiency.

- **Biomechanics, Active Human Models & Advanced Dummies**

  With the convergence of primary and secondary safety, human-like reactions, as they would occur in the pre-crash respectively low-g phase, will play a more and more important role in the development and fine-tuning of safety systems. This should be supported by research on active human models for all kinds of road users. The biofidelity and injury prediction capability of these numerical representations of the human body and in particular their ability to reproduce muscular activity need further improvements. Research in biomechanics will be the basis of such advances. So far most of the knowledge in biomechanics has been focused on so-called structural effects caused by various types of impacts. However, there is an urgent need to get a better understanding about functional effects, e.g. injuries to the nervous system frequently causing long lasting or disabling injuries.

  Human-like reactions should be introduced also in physical testing. Therefore, advanced dummies offering such features and covering a broad spectrum of human diversities should be another subject of future safety research. Further work is necessary also on improved data acquisition technology for dummies.

- **Virtual Testing**

  Computer simulations are widely used in industry to support the design of vehicle structures and restraint systems. Virtual testing offers many benefits over physical testing, such as cost reduction, robustness checks and optimisation opportunities. Virtual testing also opens the potential to cover a much wider range of traffic scenarios and human diversity (size, age, gender). Virtual testing may even be considered a necessity to develop and validate new generations of ICT-based safety systems, as conventional test methods fall short in assessing system intelligence. The main difficulty is in the reliability of models used and the lack of statistical prediction of product variability. Virtual test models and procedures are not standardised and therefore not 100% comparable between different sources. Therefore, research should be done on model validation procedures and tools, a standardised range of biofidelic human occupant models as well as on statistical modelling strategies. As an outcome of such research, recommendations should be given regarding the implementation of virtual testing in regulation.

While the above mentioned priorities have been identified on a neutral basis by the independent research providers in co-operation with external experts, the EARPA Safety Task Force members wish to reach a consensus on future automotive safety research needs with other European stakeholders and answer those needs in collaborative research projects. Therefore, EARPA invites all relevant stakeholders to discuss these research issues with the Task Force Safety.

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