European Automotive Research Partners Association

To: European Commission – DG Energy & Transport
Sent to: tren-future-of-transport@ec.europa.eu

Date: 30 September 2009

Subject: Answer to the EC Consultation on the Communication **"A sustainable future of transport: Towards an integrated, technology-led and user friendly system"**

To whom it may concern,

EARPA hereby would like to answer the European Commission public consultation on the Communication from the Commission "A sustainable future of transport: Towards an integrated, technology-led and user friendly system".

As you may already know, EARPA is the association of automotive R&D organizations. It brings together the most prominent independent R&D providers in the automotive sector throughout Europe. Its membership counts at present 33 members ranging from large and small commercial companies to national institutes and universities. For more information, please visit our website at www.earpa.org.

As such, EARPA believes it has the required expertise to provide some inputs to your consultation on the above mentioned communication, especially to the topics that are related to road vehicles as part of the mobility system.

Please note that this document is aiming at answering the European Commission (EC) questions and is formulated according to the related EC Consultation document[1]. As such, this document cannot be read as a comprehensive vision document from EARPA. It is to EARPA answer to the EC request for suggestions for policy measures to implement the European vision the EC described in its Communication for a sustainable transport system to which EARPA would like hereby to state its support.

General remarks:

1. In general the relevant elements that should form the basis for effective policy development towards a sustainable transport system are more or less covered in the Communication. The main challenge will probably not be to define policy measures for the different objectives, but to make the most (cost) effective selection of measures, taking into account the limited resources and possible counter effects caused by human behavior and unexpected market developments. Possibly new instruments to support this should be developed.
2. Reliability of the transport system should get more attention. In general uncertainties in travel time have more impact on the perceived performance of the system than the trip length itself. Related to this the predictability of travel is a major concern. For the user door-to-door predictability is a very important asset of the transport system. This means a multi-modal approach (including parking!) and adequate, up-to-date travel time prediction systems. ICT is the enabling technology to support this approach.

[1] Please see EC consultation documentation at: http://ec.europa.eu/transport/strategies/2009_future_of_transport_en.htm

3. In the EC Communication, noise is marginally mentioned under 3.3. Environmental challenges heading and under 4.3 More environmentally sustainable transport. Noise will remain a main issue in future road transport and will to a great extend influence the quality of life in large urban areas and other places near the road network. All possibilities of lowering noise levels should be taken into account, both vehicle and infrastructure related.
4. Though much attention is paid to electrification of road vehicles today we must realize that a sustainable transport system in the future will rely on a mix of energy sources and carriers. Electrification of passenger and light distribution vehicles is one of the major options for this mix. For heavy goods transport, electrification will also be an option through electrification of components and integration of hybrid systems. For long-haul transport the combustion engine will remain the main power source due to the battery weight and limited driving range in case of electrification. To meet the CO_2 reductions that are needed, all possibilities need to be used in a cost effective combination.
5. An important issue for the future will be the safety and reliability of the new ICT based systems. On one hand, these systems have the potential to further increase road safety by supporting the driver (or by even taking over some actions). On the other hand the robustness and safety of the ICT itself will be a concern. In general, the public/users will not accept failures, so reliability is an issue in itself. In addition ICT based systems may significantly contribute to the eco-driving behavior of the user (see 2. Technology) and will play a role in lowering GHG emissions from road transport.
6. Although air quality in European cities will profit from the improved emission performances of vehicles as a result of the technical improvements and EU legislation over the past decades, this subject needs integrated attention in the future. In addition to the well known components such as NO_2 and larger particulates, other contributors to air quality have to be taken into consideration. This includes the effects of alternative fuels and energy carriers on air quality and possible health problems coming from very small particulates or specific toxic pollutants, which are not yet covered by existing legislation.
7. Though most attention goes to electric cars now, the electric bicycle market shows a "silent" boost. This will have impact on mobility patterns especially in urban areas. Possibly this will lead to a modal shift from car to bicycle. On the other hand this development may possibly lead to new safety problems (increased bicycle use, longer distances, and older users). These effects need to be investigated and if in general positive this mobility mode should be promoted throughout Europe. Electric bicycles (and mopeds/scooters) will probably contribute to the consumer acceptance of electric mobility in general.

We have the following remarks and suggestions with respect to the policy issues as mentioned in the Communication.

1. Infrastructure

- The urge for further optimization of road transport (goods and persons) in terms of efficiency will influence the future composition of vehicle fleet and may lead to necessary adaptations of future infrastructure. One example is road trains for goods transport as mentioned in the Communication. Scenario studies and technology forecasts are needed to support the infrastructure planning. An example is the EAGAR[2] global benchmark study on public-funded automotive research that is currently being performed by EARPA members and funded by the EC.

[2] http://www.eagar.eu

- Develop guidelines for the design of networks with a high degree of reliability, e.g. by using lower level networks as a fall-back option. Develop code-of-practices and exchange experiences for incident management. In addition ICT could help to promote inter-modality or co-modality by improving trip organization and planning.
- Dynamic speed limits depending on the traffic and environmental situation will support both optimal use of the road infrastructure and acceptance by drivers, leading to less speed violence. The development of new monitoring and control technologies should support this (see under "Technology").
- Develop and apply European wide standards for so-called Self-Explaining Roads, roads that stimulate desired driver behavior (e.g. driving speed) by their nature. This will improve traffic safety, especially on lower level roads. Today, too many differences can be found within the EU as well as within individual Member States.
- Develop and promote the application of evaluation methodologies and models to asses cost-effective noise abatement measures for complex infrastructure situations.
- The development of dedicated infrastructure for good transport offers the possibility to introduce road trains on a large scale. The vehicles in these trains could then be connected by means of ICT, which offers further possibilities to improve fuel efficiency (relation to eco-driving technologies). Further R&D is needed to support this.

2. Technology

- After the huge improvements over the last decades vehicle technology still offers large possibilities to lower energy use and GHG emissions. For example, the estimation for the Netherlands is that a 40% CO_2 reduction in continental transport in 2040 compared to 1990 could be in reach, of which roughly half would be thanks to driveline and vehicle efficiency improvements (including weight reduction by alternative materials) and half thanks to the use of other energy sources/carriers such as biofuels, electricity and Hydrogen. The necessary technology developments need to be supported by (EU) research programs, EU legislation and economic instruments.
- It is expected that a number of alternative driveline options (HEV, PHEV, EV) will become available that will fit to particular vehicle markets on one hand and will influence the vehicle market and even the mobility of people/goods on the other hand. It is advised to perform research into these complex developments, in order to develop the optimal set of policies in this respect. New modeling and simulation tools may be needed to support policies for this, covering both technological and socio-economical aspects.
- Apart from that, the safety challenges posed by high-voltage/high-energy batteries in electric vehicles in terms of electrical and fire safety both during normal use and in vehicle crash will need special attention. Based on in-depth analyses of the resulting risks, dedicated protection strategies will have to be developed. This issue will be crucial for the long-term market acceptance of electrified vehicles. Another safety issue that needs attention is the low noise level of electric vehicles that will decrease the acoustic (warning) information as usual with vehicles powered by combustion engines. In particular this is relevant for vulnerable road users such as pedestrians and bicyclists and needs to be investigated.
- It is advised to promote the ITS technologies/services that have a large effect on reduction of energy use and GHG emissions. Studies indicate that the following technologies offer substantial advantages: Eco driving with energy use indicator and gear shift indicator, map enhanced eco driving (E-horizon systems), automatic engine shutdown, fuel efficiency advisor, tyre pressure indicators, cruise control, adaptive cruise control, cooperative cruise control, platooning, dynamic

traffic light synchronization, green waves. Some of these applications include vehicle-to-vehicle, vehicle-to-infrastructure or infrastructure-to-vehicle communication. On a technology level this will require solutions that allow to work with collected data and agreed services while respecting privacy on individual vehicle identification level at the same time.

- In important concern is the mix of vehicles with different intelligence levels in one traffic flow. This will require heterogeneous technology solutions to be fused and this should be robust. Validations of solutions and scenarios are needed and will only be possible with extended virtualization. It is suggested that the EU supports the development of these.
- Relevant will be the introduction of new types of (traffic) monitoring technologies, e.g. using new sensor technologies, combined with innovative systems for closed-loop traffic control with the objectives of improving throughput, lower the engine emissions (including CO_2), lower noise levels and improve safety.
- The broad introduction of ITS technologies into the road transport system in particular in the form of driver assistance systems could finally enable autonomous driving at least on dedicated roads, which could bring about major benefits in terms of energy efficiency, travel times, safety and comfort. If this long-term vision shall become a reality, major coordination efforts will be necessary on a European level apart from targeted R&D investments in order to guide the required evolutionary process of technology and infrastructure development.
- The emission of noise from road vehicles needs continuous attention, in relation to the introduction of new vehicle technologies such as electric vehicles, novel (light) weight materials etcetera. Further information including research priorities can be found in the recent EARPA Position paper on Noise, Vibration and Harshness, which is attached to this document. On the infrastructure side, noise reduction technologies should be promoted including low-emission road surfaces, speed adaptation depending on actual noise levels (weather dependent!), smart use of noise shields along roads, etc.
- Vehicle safety improvement needs continuous attention in view of the Vision Zero (i.e. no fatalities or severely injured persons in road traffic). There is a shift from “traditional” vehicle safety to integrated safety that includes the relation with the infrastructure and with the user as well as greater emphasis on accident avoidance. EARPA identified four main areas for future automotive safety R&D: Intelligent Safety, Structures & Materials, Human Machine Aspects and Assessment Methods. See the attached Position Paper on Automotive Safety for more information.
- Since two-wheelers will probably grow as a mode of transport in the EU (electric bicycles!), the safety of this group of vulnerable road users needs particular attention. In addition the low noise level of electric vehicles is a particular safety issue for this group that needs to be addressed. It is advised to monitor this and support the development of new safety options for this group as well as for other vulnerable road users. The growing number of elderly road users will need special attention, too.
- Besides the ‘traditional’ vehicles like passenger cars and two-wheelers alternative vehicles ‘in between’ will be introduced especially in urban areas (compare developments in India and China). These advantages and drawbacks should be investigated and possibly supported by appropriate legislation or incentives.

3. Legislative Framework

- European vehicle legislation has proven to be one of the most effective ways to make road vehicles safer and cleaner. CO_2 emission reduction will benefit from this approach as well and will help to introduce new technologies in the market.

- In addition economic instruments are effective to bring new technologies as early in the market as possible. This should be supported by well monitored pilots.
- With respect to CO_2 emission legislation, the alternative energy sources/carriers should be taken into account, in order to avoid counter effects. This includes both well-to-tank and tank-to-wheel emissions. In this respect, new test procedures should be developed that relate to the real-world impact.
- Emission legislation may be introduced in other modes of transport: shipping, air.
- Legislation on the safety of 'active' vehicle systems will be needed (traceability, qualified safety levels etc.), much like in aerospace.
- Besides legislation, standardization is needed for components and systems related to alternative fuels and energy carriers, such as connectors for electric vehicles.

4. Behaviour

- Fuel efficient driving behaviour offers substantial and cost-effective improvements in energy consumption and GHG emissions. The best way is to support this by smart eco-driving systems (see under "Technology"). This way of driving and the use of the eco-driving systems should strongly be promoted in the EU. The advantages in terms of lower energy cost for the consumer should be emphasized.
- Information about safety and environmental performances of vehicles helps consumers to make the right choices. EuroNCAP has proved to be effective with regard to the mitigation of accident consequences. While widely-accepted test and assessment methods for systems aiming at accident avoidance still have to be developed, a comparable system for energy and environment of passenger cars could have a comparable effect if the advantages for the consumer (e.g. lower fuel cost) would be clearly explained.
- Also for companies and professional drivers (independent) information about energy and environmental properties of goods vehicles will help to make better choices.
- It is generally known that financial incentives have a large influence on the behavior of consumers and drivers. E.g. tax advantages support the sale of smaller and/or low emission vehicles. Pay as you drive systems will influence mobility behavior. All possibilities to use these incentives should be investigated, e.g. by comparison of best practices between European countries. The most effective systems should be promoted in the EU, with emphasis on implementation of equal systems and methodologies in the different countries.
- There is a lot of speculation with respect to the acceptance of electric vehicles by consumer groups, e.g. related to a limited driving range. It is advised to perform consumer and market research on this subject in order to be able to develop effective policies.

5. Governance

- The transition of the transport system to a sustainable system with alternative energy sources/carriers is a long term effort that requires large investments by private and public entities. This means that government policies need to be consistent over a longer period of time. In particular this concerns legislation, economic instruments and financial incentives on both European and national level.
- With respect to the urban challenge it becomes clear that urban planning has to be done in an interactive and integrated way, considering all relevant aspects of the quality of life. New, integrated

instruments are coming available to support these planning processes. The EC could evaluate and promote these instruments for use on a regional and city level.

- An important aspect related to the development of new ICT-based transport modes and alternative power trains is the need for educated and well-skilled people working in all parts and on all levels of the transport sector. This could be supported by dedicated EU-programs such as Marie-Curie and by promoting the transport as an interesting and highly innovative sector, crucial for economic growth and with interesting challenges with respect to sustainability.

Hoping that these comments will be of interest and used by the European Commission while defining further its policy on the development of a sustainable transport system, EARPA remains at the EC disposal for any further inputs on this topic.

Should you require further information, please do not hesitate to contact either myself or Ms Muriel Attané, EARPA Secretary General (muriel.attane@tno.nl; Phone: +31 15 269 5011).

Kind regards,

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EARPA Position Paper

Further Advances in Automotive Safety
Importance for European Road Transport Research

Update, 28th September 2009

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[3]. 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[4], 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 cars with reduced carbon footprint and improved safety. This requires actions by all stakeholders from the automotive 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**. 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, which implies fast, reliable and affordable transport of persons and goods with minimum use of resources and minimum pollutant 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[5].

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:

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

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

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

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).

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 car traffic in sensitive areas such as city centres. Finally, it is important to accept that even in this ambitious scenario accidents will happen. 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.

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. 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 update process was initiated in September 2009. Grouped into four safety research areas, the following topics of major importance have been identified:

<u>Research Area 1 "Intelligent Safety"</u>

- **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 cars 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.

- **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.

- **Reliability and Functional Safety of ICT-based Safety Systems**

Safety system must offer full functionality when they are needed. Given the prolonged life cycles of modern cars as well as the growing complexity of safety-relevant electronics, securing the functionality of safety systems over the vehicle's complete life cycle forms a major challenge for the future. Software tools are now a key element to prove the dependability of electronic safety functions. Research should be done amongst others on new diagnostic standards and self-diagnosis as well as on the dependability of safety-critical software.

Research Area 2 "Structures & Materials"

- **Safety of Alternatively Powered Vehicles**

  The introduction of alternative propulsion systems poses new questions with regard to structural, electrical and fire safety. The electrification of drive trains in particular causes new challenges and, at the same time, offers new chances to improve vehicle safety. Electrical motors with high voltage and batteries for energy storage will introduce new risks. Research will be needed on how to manage electrical safety and fire safety in vehicles. New package concepts enabled by the replacement of mechanical shafts by electric power transmission will facilitate radically new design of crash structures. Also safety issues of fuel cell vehicles should be tackled. 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.

- **Simulation Tools for Impact Analyses of New Materials**

  New materials such as metal and polymer foams, composites and sandwich materials offer important opportunities for the lightweight design of crash-relevant vehicle structures. Since the vehicle development process relies to an increasing extent on numerical simulation methods, the weight reduction potential of these materials can only be fully exploited, if their behaviour can be modelled with a high degree of confidence. Further research is necessary on the predictive simulation of these materials' mechanical performances under impact loading including their failure and post-failure behaviour. Modelling approaches should be standardised, also with regard to the applicable joining techniques. Possible effects of material ageing should be taken into account.

- **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"

- **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 including crashes. 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.

- **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. 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.

  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.

- **Further Advances in Physical Testing**

  Current frontal crash test configurations have been making car front structures stiffer and stiffer. This has not only been one of the drivers of an increase in kerb weights over the last decades, but it is also critical in C2C side impact configurations. Taking into account results of up-to-date accident statistics as well as the potential of primary safety systems, research should be done on new frontal impact test methods which result in improved crash compatibility and facilitate the introduction of highly efficient lightweight vehicles with reduced dimensions.

  Stiff front structures result in high deceleration pulses of current cars, which poses a particular challenge with regard to the secondary safety of children as car occupants. Future test and assessment methods for child restraint systems should aim at more independence of test results from particular car / child seat combinations, consider a broader range of child ages and address the problem of the incorrect use of child restraint systems. Besides, protection against luggage loading should be taken into account for all kinds of (rear) occupants.

Further advances in the safety of vulnerable road users should be facilitated by new test and assessment methods for pedestrian head impact protection in the windscreen area as well as for the holistic evaluation of deployable systems such as pop-up bonnets. Moreover, research on test and assessment methods for the protection of vulnerable road users should reflect that apart from pedestrians, also cyclists and motorcyclists are exposed to a high risk of being killed or severely injured in road traffic.

Not only for these groups of road users, primary safety and driver assistance systems offer a huge potential of further reducing the number of severe accidents. However, widely accepted test methods for the technology independent assessment of the performances of such systems do not exist yet. Research should aim at laying the basis for the inclusion of these systems into consumer testing programmes, not least in order to raise customer awareness of state-of-the-art safety technologies.

While the above mentioned priorities have been identified by the independent research providers on a neutral basis, the EARPA Safety Task Force members wish to continue in reaching a consensus on future automotive safety research needs with other European stakeholders in order to 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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EARPA Position Paper

Noise, Vibration & Harshness
Importance For European Road Transport Research and FP7

24 September 2009

1. The EARPA "Noise Vibration and Harshness" (NVH) Task Force

Founded in 2002, EARPA is the association of European automotive research organisations. It brings together the most prominent independent R&D providers in the automotive sector throughout Europe. At present, EARPA counts 32 members ranging from large and small commercial organisations to national institutes and universities.

The Task Force NVH was formed in 2005 in order to discuss noise and vibration research topics of common interest and develop common positions on the importance of European automotive NVH research integrating the key elements of the road transport system – the vehicle, the infrastructure and the user. Sixteen members of EARPA form this task force[6], with expertise in all major fields of this wide domain of research.

This position paper presents an overall synthesis of the task force members' view: the relevance of research and technological development (RTD) on NVH of automotive vehicles, the definition of related boundary conditions and RTD suggestions for the Seventh Framework Programme (FP7) of the European Union and further research programmes. From the independent research providers' perspective, four major research areas were identified:

- New noise and vibration reduction technologies for propulsion systems and vehicles with low CO_2 emission, considering light-weight design, smart systems and novel acoustic materials,
- Research in specific NVH behaviour of electrified vehicles particularly for urban transport,
- Specific research in tyre-road noise with focus on electric vehicles, heavy duty vehicles and urban transport,
- Further advancing and extending of simulation tools and models for improved concept modelling and for higher prediction accuracy of noise and vibration generated by conventional, hybrid and fully electrified road transport.

2. Relevance and Importance of RTD on Noise, Vibration and harshness of Vehicles

Noise, vibration and harshness (NVH) as a field of vehicle technology has two different scopes: firstly, interior NVH aspects which include the improvement of the interior vibro-acoustic environment for the drivers and passengers and the protection against occupational health issues for the professional vehicle driver and, secondly, exterior NVH aspects aiming at the control and reduction of environmental noise emission by road vehicles.

The objectives within the first scope are determined by market needs and have achieved great progress over the last twenty years. In view of the new challenges of CO_2 reduction with the future propulsion systems, it is important to maintain the current comfort levels under the new boundary conditions imposed by the alternative drives.

The second scope is mostly determined by the social concern about environmental issues. Environmental noise emission is an attribute of the vehicle that cannot be perceived and assessed by the vehicle driver and is therefore governed not by market needs, but by governmental and EU regulations.

Over the last ten years noise impact from road vehicles has been a point of special interest in the field of the environmental effects of road transport. According to the communication "Greening Transport" [7] 32 % of the EU's population is affected by noise. Important initiatives were taken over the last ten years:

[6] Members of EARPA TF NVH: *Arsenal, AVL, CIDAUT, FEV, FhG-LBF, IDIADA, IKA, K.U. Leuven, LMS, Ricardo, SP, Tecnalia, TNO, TUE, UNIFI-DMTI, UPV-CMT*

- Directive 2002/49/EC on the assessment and management of environmental noise;
- Amendment to the Directive 70/157/EEC on the permissible sound level of motor vehicles;
- Amendment to the Directive 92/24/EC relating to the components and characteristics of 2 and 3 wheeled motor vehicles;
- Proposal for a regulation concerning type approval requirements for the general safety of motor vehicles (including tyre-road noise emission) [COM (2008) 316];
- Within the consecutive EU Framework programmes many research projects aimed at development of noise reducing technologies and noise assessment methods for road transportation noise were executed (e.g. SILENCE, HARMONOISE, IMAGINE, SILVIA, QCITY, SIRUUS, INMAR, ROTRANOMO, RATIN), as well as the CALM I and II network activities for the exchange of information and development of noise abatement strategies.

Despite all these actions and initiatives the growth of the traffic density and of the number of vehicles in use will continue. Therefore the total noise impact from road traffic is expected to rise further in the coming years. Noise emissions per vehicle in each vehicle class have decreased slightly as a result of type approval regulations and EU framework research efforts, but trends towards heavier vehicles and developments in vehicle technology (e.g. wider passenger car tyres) have more or less neutralised the effect of the noise emission reductions on a fleet average level.

Further development of low noise and vibration technology in vehicle design and construction will be needed to achieve a significant reduction of the noise emission per vehicle, and therefore of the total noise impact of road transport. Over the last year the attention for noise as an environmental issue seems to have shifted towards the problem of climate change and the related ambition to reduce the energy consumption of road vehicles. New developments in vehicle technology emerge: reduction of vehicle weight by the use of lightweight materials, downsizing of engines and the accelerated introduction of hybrid and electric vehicles. These trends will have definite influences, both positive and negative, on the NVH characteristics of vehicles. **Therefore continuous research efforts will be needed**, aiming at:

- An improved understanding of the relations between vehicle design, driving patterns and noise emission,
- The development of measures to further control and reduce the noise emission,
- Ensuring a good vibro-acoustic interior environment to strengthen the competitiveness of the European automotive industry.

3. Boundary Conditions for RTD Activities in the Field of NVH

Due to the high environmental impacts of transport such as CO_2 emission, local air and noise pollution and consumption of fossil energy resources, the activities for achieving green and sustainable transport have high priority[8] and need to be supported by further advanced and new technologies. Thus, research for reducing transport noise also has to consider all the other aspects of greening the European transport and its consequences. In addition, it must take into account the economic and market situation.

In EARPA's view, the primary boundary conditions for research and technological development (RTD) in road transport NVH are:

- Compatibility with emission reducing and energy saving technologies (e.g. low friction, light-weight design, down-sizing of engines);
- Consideration of alternative propulsion systems (e.g. hybrids, electrification, range extenders, fuel cells);
- Safety aspects (e.g. electric vehicles too quiet for pedestrians, wet grip of low-noise tyres, low/uncommon system feedback to drivers);
- Cost competitiveness (e.g. in comparison with conventional power trains and vehicles);

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[7] SEC(2208) 2206: Commission Staff Working Document on Greening Transport, Brussels, 8.7.2008.

[8] COM(2008) 433 final: Greening Transport, Brussels, 8.7.2008

- New mobility requirements;
- Ecologically friendly technologies (e.g. the use of natural light–weight materials, recyclability).

4. Research Needs and Suggestions for FP7 and further research programmes

Greening the European transport system requires vehicle manufacturers to adapt a new way of developing vehicles. Power train and transmission systems are in a fundamental change (electrification, hybrid etc.), and vehicles and engines must be scaled down to reduce weight, cost and fuel consumption. At the same time, the current high levels of other vehicle attributes such as safety, NVH and reliability have to be maintained. In addition, quality and efficiency of development and production must be improved, to achieve vehicles that are not only clean, safe and reliable, but also competitive in the end.

This necessitates adaptations and supplements in the research needs as defined in previous research agendas[9, 10].

Under consideration of the primary boundary conditions as described above, the EARPA NVH Task Force sees the following four major fields of NVH research needs:

A. New noise and vibration reduction technologies for propulsion systems and vehicles with low CO_2 emission, considering light-weight design, smart systems and novel acoustic materials

- Low noise technologies for light-weight design of both propulsion systems and vehicle structures,
- Development/adaptation of novel acoustic materials (such as high damping materials, metal or other structural foams, meta-materials etc.), in particular for use in urban road transport,
- Development of smart systems for improved NVH behaviour (e.g. piezo-electric actuators for active vibration/noise cancellation) and their integration into the vehicle.

B. Research in specific NVH behaviour of electrified vehicles particularly for urban transport

- Investigation of the noise behaviour of electrified propulsion systems and identification of the related NVH requirements and achievable targets including sound quality aspects,
- Noise reduction technologies for NVH critical elements of electrified propulsion systems such as electric motor, electric converters, range extender unit, cooling system, air supply and compressor of fuel cells,
- Noise performance of electrical auxiliary aggregates of (electrified) freight vehicles,
- Quiet burners for cabin heater system of hybrid vehicles,
- Investigation on the need of a minimum noise emission from electrified vehicles for safety reasons.

9 ERTRAC Strategic Research Agenda Overview, Oct. 2004 (www.ertrac.org)

10 CALM Strategy Paper, "Research for a Quieter Europe in 2020", Sep. 2007 (www.calm-network.com)

C. Specific research in tyre-road noise with focus on electric vehicles, heavy duty vehicles and urban transport

- Investigation of tyre-road noise generation of electric vehicles and heavy duty vehicles especially in urban traffic under steady and transient driving conditions (such as braking, curves, acceleration etc.),
- Quiet road surfaces dedicated to urban areas for less generation of tyre-road noise and reduction of noise propagation to surrounding (residential) areas.

D. Further advancing and extending of simulation tools and models for improved concept modelling and for higher prediction accuracy of noise and vibration generated by conventional, hybrid and fully electrified road transport

- Improvements in concept modelling and simulation for providing reliable NVH concept and design aspects in early design stages (enabling more efficient frontloading of the design engineering process),
- Improved modelling of the actual dynamic source loading and the most relevant damping mechanisms (including non-linear effects),
- Extension of current NVH simulation methodologies to the mid-frequency range for conventional, hybrid and fully electrified vehicles,
- Adaptation of models for coupling computational fluid dynamics (CFD) with acoustic approaches for reliable prediction of flow-induced noise and vibration (e.g. in intake and exhaust systems, wind noise etc.),
- Extension of models for noise and vibration prediction of alternative propulsion systems,
- Extension/adaptation of prediction models for the behaviour of advanced acoustic materials such as multi-layer trim components, novel light-weight structures, meta-materials, visco-elastic materials etc.,
- Further advancing of probabilistic methods to treat uncertainty and variability effects on the dynamic response, in particular for use in large (vehicle) NVH models,
- Development of modelling paradigms for sound engineering of new generation transport vehicles (e.g. modelling for sound quality).

The EARPA Task Force NVH sees the requirement to carefully identify research topics on a European level in close co-operation with all relevant stakeholders. Taking advantage of their expertise, EARPA members can offer support to this identification process on a neutral basis. Moreover, EARPA invites all stakeholders to discuss the above research issues with the Task Force NVH.

The EARPA Noise Vibration & Harshness Task Force

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