Road Transport is at the heart of some of the most significant Societal Grand Challenges. The importance of energy security and sustainability, climate change, environmental issues and road safety are increasingly well understood, the need for accessible, affordable and robust mobility is appreciated by our increasingly urbanised populations; the recent global financial crisis has underscored the need to further enhance European competitiveness. The implementation of new technology, encouraged by grant-supported research activity, is key to bringing about the paradigm shifts needed to meet these challenges.

The positioning of EARPA’s members, combining exposure to commercial product development with links to academic research, has enabled them to make a valuable contribution to the European Research Area, in terms of research delivery, innovation and strategic vision. Through the activities of EARPA themed Task Forces, ideas and priorities for research are developed and shared with stakeholders and European Technology Platforms. EARPA members have supported the development of the new 2018 ETRAC Strategic Research Agenda, “Towards a 50% more efficient road transport system by 2030”, and are regular participants in European Framework and Member State supported research programs, contributing to the development of many key transport technologies.

This document brings together EARPA viewpoints on European research towards the Eighth Framework Programme (FP8), both from the holistic context of European research versus global benchmarks, and with insight into individual technological areas. Key points made are:

- The importance of automotive research is driven not just by the direct contribution of the sector to Gross Domestic Product, but also by its influential impact on a number of Societal Grand Challenges.
- The effectiveness of European research can be improved through better coordination between European and National research agendas, recognising that different types of research may be better suited to one or the other – limited budgets mean that European-level research needs to focus on those areas that benefit most from European-level integration, whether to solve technological or infrastructural hurdles.
- The effectiveness of European research can also be improved by implementing best practises from around the world to create accessible, responsive and flexible research instruments.
- The issue of Poweering Road Transport – the supply of sustainable energy and low carbon propulsion technology – will remain a key one for many decades. Game-changing solutions such as Electrification and the Hydrogen / Fuel Cell pairing require technological progress to migrate to the affordable mainstream, but this process will not be instantaneous, and the potential of improved internal combustion engines and lower-carbon liquid fuels (especially bio-fuels) should not be overlooked.
- A spectrum of technologies can deliver an Intelligent, Safer and Greener Future for Mobility – meaning that serious accidents, environmental impacts and disruption to mobility through congestion are reduced towards zero. Holistic approaches are required to achieve results through a combination of intelligent vehicle and infrastructure technologies, which maximise the utilisation of existing road infrastructure, with enablement through policymaking and behaviour change.
- Research into enabling technology building blocks such as materials, embedded systems, and simulation tools is vital to realising the implementation of the technologies above.

This document contains numerous references to EARPA’s other works in this field. EARPA hopes that, by bringing these to your attention, we can continue to be a strong contributor to a future where the Societal Grand Challenges of road transport are successfully addressed by future European and National research funding programmes.
In July 2009, a conference on research and innovation was held in Lund, Sweden, hosted by the Swedish Presidency of the Council of the European Union. Here, around 350 researchers, policy makers and representatives from industry and research funding institutions agreed on the Lund Declaration [1], which stated that European research policy should focus on global ‘Societal Grand Challenges’ such as climate change, water shortage and pandemics.

Road transport is a part of these Societal Grand Challenges in many ways: emissions from transport propulsion lead to concerns over air quality and climate change; the death toll from accidents remains unacceptable; rising pressures on the road infrastructure create social burdens of noise intrusion, air quality issues and reduced accessibility to mobility; and the economic success of the road transport industries is pivotal to Europe’s economic health. Grand Challenges can be addressed in many ways, from changes in economic drivers and public behaviour, to the encouragement and introduction of new technologies. In road transport, both the technologies and the behavioural aspects of the vehicle’s user and infrastructure at large are becoming increasingly interwoven through, for example, intelligent transport systems and new transport energy infrastructures. Therefore, there is now a powerful need to perform research into technological and socio-economic solutions.

The objective of this paper is to look at these Grand Challenges in the context of road transport issues, and draw upon the expertise of EARPA specialist Task Forces to postulate some areas of priority for public support instruments that address them – such as the forthcoming Eighth Framework (FP8) programme.

The Global Context

Sustainable Economic Competitiveness
Building an Inclusive Society
Energy and Environment
Climate Change, Security of Energy Supply
Local Air Quality, Traffic Noise in Communities
Safe Secure Mobility
Safety of all road users
Freedom from Congestion
Universal access to Mobility
Areas of Challenge

Road Transport and Societal Grand Challenges

Road Transport issues

Road transport industries account for 11% of Europe’s GDP, and face rising pressure from developing economies. Building competitiveness through the virtuous triangle of research, education and innovation is essential to secure wealth generation and employment.

Road transport industries provide a spectrum of employment, from high value engineering and technology, to semi-skilled manufacture and construction. Maintaining this balance supports balanced employment and wealth in society as a whole.

Road transport in Europe consumes 33% of imported fossil fuels (oil and gas) and accounts for 17% of manmade greenhouse gases. Reduction in energy use, and transition to more sustainable energy chains, are vital to achieving both security and environmental objectives.

Significant progress has been made in improving air quality and reducing noise emissions from vehicles, but rising traffic volumes and desire for higher standards result in ongoing need for cleaner, quieter transport.

Road traffic accidents are responsible for 35,000 fatalities every year. Technological solutions and improved human and behavioural understanding can reduce this figure toward the ultimate vision of zero fatalities and seriously injured road users.

Congestion is an issue where historic change has often been in the wrong direction. Delays and uncertainty over travel times have an estimated cost of around 1% of Europe’s GDP.

Road transport, by private or public vehicle, is essential for a cohesive European society. Rising cost, driven by meeting other challenges, must not be allowed to deny access to mobility to the less wealthy.

European Research in a Global Context

In 2000, the European Council launched the concept of the ‘European Research Area’, and set the challenging target of increasing research expenditure from 2% of Gross Domestic Product (GDP) to a level of 3% by 2010. This investment is the mechanism by which Europe maintains its advantage in terms of value-added economic competitiveness and a healthy social environment; and co-funding of research by the European Commission and Member State governments is a key mechanism to promote and focus research effort. While the desired increase has not yet been achieved, the past decade has seen the introduction of many innovative funding and financing instruments, including Integrated Projects, wide-scale Networks of Excellence, Joint Technology Initiatives and Public-Private Partnerships, together with the ERA-Net trans-national co-operation mechanism and the European Investment Bank’s Risk Sharing Finance Facility.

However, over the past decade the rest of the world has not stood still. China now ranks alongside the EU-27 and USA as a major player in science and engineering research, while Japan and Korea now spend over 3% of GDP on research [2]. Europe faces the challenge of competing while balancing the budget and marshalling the efforts of 27 Member States.
The EAGAR project
In 2008, EARPA initiated the EC co-funded project “European Assessment of Global Publicly Funded Automotive Research – Targets and Approaches” (EAGAR, [3]), with the objectives of developing a robust methodology for the global analysis of funding structures, visions, research targets and programmes, and benchmarking public automotive research activities at international level. This program has developed many recommendations, with these being seen as key:

• Public investment in automotive research and technology development (RTD) should be strongly competitive with other major economies
• Public investment in automotive RTD appears to be most efficient and easy to access when directed through fewer organisations, or ideally one organisation
• A regular consultation process that includes all stakeholders should be established to define RTD programmes
• Targets for Europe’s competitiveness should be established that are understandable, measurable and supported by dedicated RTD programmes
• Research agencies should be aware of, and endeavour to apply, best practices from the European and global arena, especially funding structures and execution processes
• Online information about research programmes and supported projects improves the automotive RTD funding process at all levels and encourages more international collaboration

The EAGAR project found that most major economies spent more on automotive research than one would expect from the sector’s contribution to GDP, almost certainly as a result of the sector’s importance to the Societal Grand Challenges. The EC is no exception, lying in line with the US, China and individual EU economies such as Germany.

Research Agenda – Evolution or Revolution?
Road transport technology has historically followed an evolutionary path, with many small steps combining to achieve significant and remarkable progress in reliability, safety, comfort, performance and environmental impact. In 2003, EARPA published the results of the FURORE technology roadmap [4], which concluded that this evolutionary approach, promoted to a “fast track” pace by strategically focused research, would be well placed to meet the challenges of 2020 and beyond. By 2004, the European Road Transport Advisory Council (ERTRAC) brought together stakeholders from all aspects of road transport (including EARPA) to deliver a Strategic Research Agenda that reached a similar conclusion of focused fast-track evolution [5].

The past decade has brought about as much change in technological drivers as it has in global economics. Rising energy prices and environmental pressures, and the relentless advance of electronics, computing and IT system performance, create an environment for paradigm shifts in road transport technology. Yet underlying those shifts there will remain a strong desire to maintain the evolutionary approach (albeit at an even faster pace), driven by “ sunk costs” and the risks inherent in totally revolutionary mass-market change. It is essential that future strategy for European road transport research balances these factors carefully, mixing fast evolution of the mass market with the creation of more revolutionary niches.

In 2010, ERTRAC has published a new Strategic Research Agenda [6], which was developed with input from a broad, balanced cross-section of stakeholders and lays out a framework for future change, to be taken into account in setting FP8 transport research priorities. As before, EARPA members have made a significant contribution to this SRA, and its guiding objectives are considered to be realistic and well aligned to EARPA’s technical visions, which are discussed in the following sections.

European Research in a Global Context

The EAGAR project focuses on the competitiveness of European research at international level, in terms of strategies, priorities and budgets. The project completes in 2010, and will deliver:

• Overviews of Member State road transport visions, roadmaps and programmes
• Comparison with research priorities in North America, Japan, Korea, China and India
• Discussion of areas of strength and weakness, and recommendations for improving international co-operation and competitiveness

Information is available at www.eagar.eu

Overview of global publicly funded automotive research (in 2007, without regional funding).

<table>
<thead>
<tr>
<th>Country</th>
<th>Importance of Automotive Research</th>
<th>Importance of Automotive Industry (Automotive Turnover / GDP)</th>
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<tbody>
<tr>
<td>US</td>
<td>1658</td>
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<tr>
<td>CN</td>
<td>213</td>
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</tbody>
</table>
The transformation to a global sustainable economy will be the greatest act of technological and socio-economic engineering ever undertaken, and therefore constitutes the world’s greatest Grand Challenge. It will require unprecedented levels of international collaboration; forward planning and investment well beyond the horizons of normal commercial enterprises; and sustained, focused research and technology development (RTD) effort to advance the capabilities of today’s sustainable energy technologies to the point where they are compatible with commercialisation in a future global market. The issue is particularly acute for transport, because the energy storage density and low cost of today’s liquid fossil fuel solutions are so hard to match with sustainable technologies.

The broad long-term policy of Europe, and many of the world’s other major economic powers, is for a sustainable or zero carbon energy supply based on energy distribution in the form of Electricity, Hydrogen and Biofuels. The European Commission’s Strategic Energy Technology plan [7] calls for cost-competitive second generation biofuels, fuel cell / hydrogen technologies, and low carbon electricity distributed over smart grids, to provide transport energy; and reinforces the need for breakthroughs in nano-, bio-, and information technologies as enablers.

The clear view of EARPA members is that the future transport energy landscape will be more complex, with no single solution able to emerge as an universal “winner” in the way that liquid fossil fuels have over the last century. Over the past decade, Hydrogen, Biofuels, and now Electricity, have enjoyed fashionable status; the reality is a future embracing all three in appropriate applications, alongside fossil fuels which could still provide a significant (25-50%) share of road transport energy in the period 2030-2050 [6]. Looking towards 2050, it is most likely that electricity and hydrogen will find most favour in passenger cars and light goods vehicles and buses, while biofuels may provide a non-fossil solution for long-haul trucks.

**Electrification and the Plugged-in vehicle**

EARPA’s Task Forces on Hybrid and Electric vehicles, systems and components have produced a paper describing their current status and future technology needs [8], using the input from the ‘Electrification of Road Transport’ roadmap (ERTRAC, EProS and SmartGrids, [9]). Electricity is entering the vehicle in two forms. In Hybrids, it is used as a temporary energy source, capturing otherwise wasted braking energy and re-using it in a variety of ways, from powering ancillaries and re-starting the engine, to full electric propulsion for a limited range – but in these vehicles, a conventional fuel is the prime source of power, via a combustion engine. A first generation of European Hybrid vehicles is now entering the market, but there remains significant scope for research into future generations of Hybrid that exploit better the synergy of reversible electric energy storage with re-configured internal combustion engines. More extreme engine down-sizing (in which the hybrid system mitigates poor turbocharger response), and greater exploitation of efficient, clean combustion modes, will be key technologies. Increasingly, these will be geared to the use of bio-fuels; on the side of the hybrid system itself, lower cost through modularisation, integration and technology advances (including non-electric hybrids) will be key enablers.

In the plugged in vehicle, Electricty becomes a “fuel” in its own right. As with Hybrids, there is a spectrum of technologies, from plug-in Hybrids with a slightly larger battery and onboard charger that have perhaps just 20km urban-use electric range, to full electric vehicles with no other power source and much more range. In contrast to the Hybrid, there is not yet a proven first generation of technology, although this situation is expected to change over the 2010-2015 period. There are three key factors which must be addressed. The cost of electrical systems, especially the battery; mitigation of “range anxiety” through better energy storage and more efficient use of stored energy; accurate prediction of range, and auxiliary power (range-extending engines); and development of a more extensive re-charging infrastructure, embracing more charging points, then fast charging and intelligent grid integration that can manage charging power flow as part of a smart system.

**Hydrogen as a complementary choice?**

Like Electricity, Hydrogen is a fuel that can produce no emissions at the point of use (by using it in a fuel cell). EARPA members took a lead role in the recently published Road2HyCom study [10], which examined technical and socio-economic issues related to the uptake of Hydrogen and Fuel Cell technologies in the broader context of a sustainable energy economy. Currently considered less fashionable than Electricity as an energy vector, Hydrogen offers greater operating range and faster refuelling. The Fuel Cell is an efficient device to turn Hydrogen to motive power, and the study found that it could be approaching technological maturity and market uptake, though non-road applications such as goods handling, power and heat-power generation are lead markets in terms of known product volume. Early road transport markets are likely to be delivery vehicles and buses, whose operating range requirement is beyond that offered by a battery, but where cost, hydrogen filling time and low and sustainable fueling create conditions for uptake. In the longer term, the Hydrogen / Fuel Cell pairing has a good synergy with vehicle electrification, and could provide range-extending capability to Electric vehicles, using a smaller network of Hydrogen stations concentrated around trunk routes. Key technical enablers for this are cheaper Hydrogen storage, productionisation of rugged automotive Fuel Cells, and the development of an infrastructure to supply affordable, sustainably produced fuel – which itself needs to be linked to broader energy policy [10].
A new generation of Biofuels

Biofuels will play a significant role in the transition to sustainable transport. In the recent past, the key issue has been that “first generation” biofuels have used food crops and energy-intensive production processes, meaning that their greenhouse gas performance and land-use efficiency have been questioned, and their uptake has been linked to increases in food prices. However, a second generation, based on specific energy crops, residues and other wastes, or use of organisms such as algae, offers substantially better performance with far less negative social impact [11]. Furthermore, if correctly formulated they can be back-substituted into the existing vehicle park. The consequence of this is that medium term impact can be large: The new ERTRAC SRA [6] states an objective that 25% of the road vehicle energy pool will be Biofuel by 2030 – in practice it may be that this penetration can be applied as blended fuel to the entire in-use vehicle parc, enabling second generation fuels (with an average 67% well-to-wheel greenhouse gas benefit over fossil fuels) to deliver an overall reduction in road transport CO2 of 16%. The same document indicates a 5% substitution of fossil fuel by Electricity in the same timeframe (which, since it can only be applied to new vehicles, requires 10-15% of new vehicles to be electric). If these EVs have around half the well-to-wheel carbon footprint of a contemporary liquid fuelled hybrid vehicle [12], their contribution to overall road transport CO2 reduction is circa 3% - or one-fifth of the contribution of Biofuels – unless substantial increases in carbon-free electricity generation can improve the benefit. Although the balance could shift in favour of Electricity and Hydrogen in later years, Biofuels – and the internal combustion engines that use them – remain vital topics for research over the coming decade.

Biofuels will also become sought-after energy vectors for the air, marine, and non-electrified rail sectors, as onboard storage of Hydrogen or electricity is likely to remain infeasible here. Linking the strategic visions of these sectors in terms of their demand for Biofuel or biomass is therefore vital, and an action of this type needs to be undertaken at least at European level.

Powering Road Transport

**EARPA’s position on Biofuels**

- Biofuels with good environmental and social credentials will play a major role in decarbonising road transport, because they are highly compatible with incumbent IC engine technology, and can be applied to the whole fleet, not just new vehicles.
- Robust, standardised methods are required to establish the life-cycle environmental credentials of biofuel production processes.
- Further research is needed to develop second generation production processes to the point of large scale commercial maturity; a pipeline of innovative processes should be established.
- The optimisation of engine technologies to match the properties of these new fuels requires ongoing research, embracing sensing, smart adaptation and new combustion / after-treatment processes.

**Hydrogen and Fuel Cell research**

Roads2HyCom’s research priorities [10]

- Cost-effective, low-carbon or renewable Hydrogen production
- Low cost, energy dense Hydrogen storage in vehicle
- Realisation of Fuel Cell production processes
- Fuel Cell durability and impurity tolerance
- Thriving of processes metals and other system cost reductions
- Maintenance and Diagnostics for H2/FC systems
- Standardisation and development of standards
- Identification and support of technologies for early markets

Roads2HyCom was a project under the sixth framework program, delivered by a team including seven EARPA members.
The continuing importance of Internal Combustion

Finally, it is important to understand the continuing role of the Internal Combustion Engine (ICE). In the heavy duty sector, requirements of load factor and range mean that the ICE, albeit in improved form and using more sustainable Biofuels, could remain the long term solution. In all applications, new control technologies (taking information from inside the engine and from navigation / routing systems) have the potential to address local environmental issues through clean operating modes. And as described above, the combination of hybridisation, advanced ICE, advanced control system and more sustainable liquid fuel will set increasingly high standards for the alternatives [12]. Even in the light duty sector, it is expected that over 80% of vehicles will use an ICE in 2030 [6]. Many of these may have plug-in electric capability for shorter journeys, but of course longer journeys consume more energy as a result of their greater distance and speed. Therefore research into improving the ICE (and its control system), in all applications, remains important alongside research into the alternatives.

The efficiency of the ICE is limited by the Second Law of Thermo-dynamics, which links it to the temperature of combustion. This in turn is limited by the formation of harmful "NOx" emissions at higher temperatures, creating a theoretical efficiency limit of around 70-75%. For comparison, the best contemporary prototype heavy duty engines with exhaust heat recovery are achieving up to 55% efficiency, but only at an optimum operating condition. In practise, most engines operate at below half the theoretical optimum efficiency. It is this deficit that the research agenda must address. In the heavy duty sector, steady state efficiency is key, and technologies such as reduced friction, high efficiency combustion and after-treatment, tailored fuels, and the recovery of waste heat must be developed as a priority. Light duty engines are more transient in their operation, and will benefit from these technologies plus the optimisation of the warm-up process, further down-sizing, and matching to new hybrid and range-extender applications.

Why the Internal Combustion Engine has an important role in the future

• The combination of ICE and liquid fuel offers low system cost, good driving range, easy re-fuelling and consistent efficiency over a wide range of real world conditions
• The ICE can be made more efficient through technologies like down-sizing, hybridisation, and exhaust energy recovery
• In the heavy-duty sector, the challenges of storing sufficient electricity or Hydrogen for a viable long-haul truck unit, mean that the ICE is likely to remain the only feasible solution for several decades
• Improvements in efficiency, combined with increasing use of Biofuels, means that an ICE powered vehicle can have competitive environmental credentials to the alternatives on a real world, well to wheel basis

Alternative Propulsion Glossary

There are numerous terms used in alternative propulsion, here are the key technologies:

Hybrid Vehicle – A vehicle with two sources of propulsion. One of these usually captures energy when the vehicle slows down. Most common is the Hybrid Electric Vehicle (HEV)

Mild Hybrid – A hybrid where the second source of propulsion plays only a small role (such as helping with acceleration) and cannot power the vehicle alone

Full Hybrid – A hybrid where the second source of propulsion can operate alone – usually an electric drive mode

Plug-in Hybrid – A Full Hybrid with extended battery capacity and re-charging ability – a full charge typically gives 10 - 20km range

Electric Vehicle (EV) – A vehicle powered only by electricity, re-fuelled by re-charging or battery swap. Range typically 50 - 200km

Range-extended Electric Vehicle (REEV or EREV) – An EV carrying a second power source, such as an engine or fuel cell, to provide extra range and easy re-fuelling once the battery is depleted. Unlike a plug-in hybrid, the auxiliary power unit (APU) has no mechanical drive to the wheels

Fuel Cell – A device that turns a fuel (usually Hydrogen) into electricity – which in turn can be used to drive a vehicle

First generation Biofuel – A liquid or gaseous fuel made from human or animal food crops (sugar/starch or oil-bearing), and wastes (vegetable oil)

Second generation Biofuel – A liquid or gaseous fuel made from bio sources with low environmental and social impact - typically non food crops, crop wastes, wood residue, other wastes, and algae
A vision for Safety

EARPA members have developed vision for future safety and mobility [13, 15], which are 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. However, mobility should still be efficient, which implies fast, reliable, convenient and affordable transport of persons and goods with minimum environmental impact. 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 [14].

Realising this vision will require an integrated approach, embracing infrastructure, vehicle and user. This must be reflected by the characteristics of the future road transport system. An intelligent, robust infrastructure, must be designed to provide for the needs of different kinds of road users, both in terms of physical hardware and enabling electronic systems. New vehicle types will be required, combining lightweight structural designs that are compatible with other vehicles and vulnerable road users in the event of accidents, with suitable intelligence to use sensor and communications information to enable accident avoidance and mitigation in a way that users find intuitive; ultimately this capability will pave the way for autonomous driving, which will be able to offer the user increased safety and the opportunity to spend wasted driving time on other things. Finally, 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, not just in terms of safe and legal driving but also acceptance of new technologies, including traffic management, travel information and “co-modality” – mixing transport modes (car, bus, train) with the assistance of an intelligent system.

Although there have been major improvements in road safety in recent years, Europeanfatality statistics still indicate that the European Commission’s target of halving fatalities from 2000 to 2010 will not be met. In the developing world, with poorer standards of infrastructure, regulation and vehicle, the situation is far worse. Progress in the reduction of road fatalities achieved so far is to a large extent due to intensive research efforts by the European automotive industry and its partners, encouraged by initiatives such as the European New Car Assessment Programme (Euro-NCAP). This has put the European industry in a leading global position, which needs to be maintained as a competitive advantage. 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 road transport with reduced carbon footprint and improved safety.

All over Europe, the trend towards urbanisation is expected to continue, with the proportion of the European population living in urban areas predicted to increase from 72% in 2007 to 84% in 2050 [15]. Accordingly, urban mobility is of growing concern to citizens and authorities, because cities and urban areas need efficient transport systems to support their economy and the welfare of their inhabitants. Today, urban areas face the challenge of making transport sustainable both in environmental (CO2, air pollution, noise) and mobility / competiveness (congestion) terms while at the same time addressing social concerns. Increased traffic in urban areas has led to chronic congestion all over Europe with nearly 100 billion Euros (1% of Europe’s GDP) being lost every year as a result [15]. Urban traffic accounts for 40% of CO2 emissions and 70% of other pollutants arising from road transport [15]. In addition, other societal trends such as the ageing population and shifts in lifestyles need to be addressed in future passenger and goods transport solutions.

A vision for Safety

EARPA research priorities for Safety - Vision Zero + Efficient Mobility [13]

- Intelligent Systems: Integrated Sensing, Vehicle Dynamics, Driver Monitoring
- Vehicle-to-X communication and Integrated Traffic Applications
- Advanced Controls as Evolutionary Step towards Autonomous Driving
- Safety and Crashworthiness: Electrified Vehicles, Batteries, Design for Downsizing, Active Structures & Smart Materials
- Humans: Protection of Vulnerable Road Users, Adaptation to different User Groups
An Intelligent, Safer and Greener Future for Mobility

Mobility for All

Realising a vision for Efficient Mobility requires attention to more than just the "hard technologies" of the vehicle and its infrastructure. For example urban planning, pricing policies, safety control, environmental impact, economic assessments, maintenance of accurate data and statistics, policy measures, traffic management and organisation are all becoming more and more relevant. And with pressure on land use, maximising the use of existing road infrastructure is an important over-arching need.

EARPA has created a new 'horizontal' Task Force on urban mobility, dealing with technical and non-technical issues related to the demand and implementation side of technology in urban mobility, which has identified four areas of priority for action [15]. Electric Mobility (including not just the vehicle and re-charging hardware, but also the mechanisms of regulation, transaction processing etc., as well as gaining public acceptance) is potentially a game-changing trend, requiring both technology issues (as described previously) and the business-model (new models for accessing and paying for transport) to be addressed. Intelligent Transport Systems (ITS) is a broad topic covering the technologies of communication between vehicles and infrastructure, how the information is used on vehicle and in managing traffic, and defining how new services may be offered to road users, from simple provision of information, to enablement of future semi-autonomous driving functions like platooning. Taking the ITS principle further, Co-modality (linking road transport to other modes in more seamless ways) has ultimate potential to bring about shifts in the efficiency of multi-mode freight and the uptake of public transport. Finally, it is also important to understand the impact of new technologies on the environment and quality of life - meaning a holistic study of acceptance issues and the complex shifts in behaviour that may result.

As well as addressing a major challenge, this intelligent future for mobility also creates some new ones. An intelligent transport system must be robust to a long transition period where new, intelligent vehicles mix with older, non-equipped ones, meaning that the new technologies have to operate safely in all circumstances. This is a significant, but not insoluble, challenge for semi-autonomous driving systems such as accident avoidance and platooning. There are also commercial challenges, with new stakeholders from other domains (ICT, service providers, energy companies) becoming part of the transport business model. However, this particular challenge is also an opportunity for stimulating paradigm shift in technologies or the public and political opinion.

A Cleaner, Quieter Europe

Of course even a safe and efficient road transport system brings other issues which impact upon local quality of life. While there have been major improvements in urban air quality thanks to the regulation of exhaust emissions, it remains desirable to do more – while electrification removes the pollution problem from the locality of the roads, it places it into the field of power generation; and in sectors such as inter-city mobility and heavy trucks where it is least applicable, the advanced combustion-engine technologies discussed in the previous section must be clean as well as carbon/energy efficient.

Noise from road transport is a challenge with two facets. First, new technologies bring new challenges to noise inside the vehicle – for example, the conflict between weight reduction and acoustic refinement, or the safety issues arising from the new relationship between perceived noise and speed seen in an electric vehicle. Second, growing traffic volumes mean that environmental noise is a growing concern. Usually it is the presence of noise that is an issue, adversely affecting working and living environments (according to the communication "Greening Transport" [16], 32% of the EU's population is adversely affected by noise pollution); however, with electric vehicles the absence of exterior noise at low speeds is also an issue affecting the safety of pedestrians and cyclists.

EARPA research priorities for Noise [17]

- New noise and vibration reduction technologies for propulsion systems and vehicles with low CO2 emission, considering light-weight design, smart systems and novel acoustic materials
- Research in the specific noise, vibration and harshness (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.
An Intelligent, Safer and Greener Future for Mobility

**Enabling Technologies**

Finally, there are two key enabling topics which EARPA consider important. Materials technology is at the heart of many of these challenges, enabling light, crash-safe and sound-absorbing structures for vehicle and road infrastructure alike. It is also at the heart of the energy challenge (providing technologies for alternative energy storage such as batteries, and for lighter vehicles requiring less energy in both construction and use) and the implementation of intelligent transport (in particular, realisation of lower cost sensors). In some cases, major mineral resources or supply chains lie outside the EU, creating increased economic exposure, and a need to find alternatives based on more local or abundant resources - magnetic materials, essential for vehicle electrification, being a major example. It is therefore important that that materials research is supported, from the development of new generic technology in the science base, through to application-focused research for road transport.

**EARPA research priorities for Materials**

- Tailored design of materials and material systems meeting the requirements of road transport
- Implementation of those materials and material system in road transport-related applications
- Production and manufacturing of those materials and components made from them
- Life-cycle including recycling of those materials and components

**Virtual Engineering: Key topics for Modelling & Simulation research**

- Energy Conversion – simulation of vehicle energy balances (power, waste heat, energy losses), ICE combustion and exhaust catalysis, modelling of electric vehicle systems, motors (electromagnetics) and batteries (electrochemistry)
- Structure & Safety – Crash performance of lightweight structures, robustness and virtual testing of active safety systems
- Noise Transmission – Structure-borne and air-borne noise permeation, with a focus on emerging technologies

Over the last twenty years, the use of virtual engineering has become more widespread, with benefits to the speed of product development and the qualities of the product. With the technology challenges of safe, sustainable transport ahead and the competitive nature of the market, design engineers face the complex problem of meeting ever expanding but often conflicting design criteria. The state of the art in modelling and simulation tools, and associated computing power, is now advancing to the point where competitive advantage can be gained from virtual processes that flow seamlessly from concept selection, through detail engineering, to implementation of robust model-based electronic controllers. These tools will combine system-level models, which characterise whole systems such as a vehicle via models of its major components, and multi-dimensional tools, which use increasingly sophisticated mathematical techniques to model critical parts in great detail. Validation from first principles of the physics captured in these tools is necessary to ensure that they can be relied upon in a commercial engineering environment.
It is clear that road transport research will have a major role to play in meeting Societal Grand Challenges, whether they relate to security of energy supply, creation of a safe and clean environment, provision of affordable mobility, or economic competitiveness in global markets. It is also clear that state aid to research and technology development is a reality across the globe [3]. Therefore it is essential that Europe’s research program, including the forthcoming FP8, is globally competitive in terms of focus, funding and flexibility.

With the Commission’s own Framework Program accounting only to around 20% of the total public research expenditure in the EU-27 [3], it is impossible to cover every aspect of road transport research comprehensively. The question then becomes: should there be broad coverage of many topics with limited budgets, or more in-depth coverage of a few areas of focus? The EAGAR project [3] found that the different sources of research funding available in Europe could each be better suited to different stages of technology maturity – but the relationship depends on what is limiting the market uptake. In the case of a technologically limited item (such as the creation of a new battery cell chemistry with greater energy density and lower cost), bringing together basic researchers from across Europe to pool knowledge and achieve breakthroughs, may be the best use of the highly integrated coverage of a few areas of focus? The EAGAR project [3] found that the broad coverage of many topics with limited budgets, or more in-depth coverage of a few areas of focus?

The pressing needs of the environment, society and global competitiveness mean that a paradigm shift is required in the delivery of new technology solutions, from concept to widespread implementation. Research lies at the heart of this process; the delivery of timely, implementation-ready research outputs is key to the paradigm shift.

For best effect the European Research Area requires Focus, meaning strengthened coordination between the Framework programme and National (member state) agendas (EARPA welcomes the initiatives under way to encourage such coordination in the future), and more effective mechanisms for learning from research to be fed back into Policy. It also requires adequate Funding, meaning that the importance of Road Transport technologies must be recognised on an enduring basis and that the associated investments are considered in the global economy.

Finally, flexibility must be shown in the way the delivery process is structured, meaning that processes for setting research agendas, creating proposals and delivering research are continually streamlined, adopting the very best practices from around the world.

The efficient delivery of research requires the engagement of the right mix of stakeholders, from academia through to manufacturers and end users of goods or services. Within this mix, an important role is played by Research and Technology Organisations (RTOs), including national laboratories and independent commercial providers of technical services. A recent survey by EARTO [20] found that RTDs constituted 28% of the participation in the Framework Six program, and received 32% of the funds.

In the Road Transport sector, EARPA members perform valuable and innovative services to other stakeholders. Contract engineering for manufacturers and suppliers is the mainstay of some EARPA members’ business, providing a range of services from specialist engineering (for example, developing an engine to an emissions standard or a vehicle body to a crash safety standard) to whole product delivery (engineering a product from clean sheet design to in production issue resolution). Others perform valuable services to Government, including the provision of recommendations for regulations and standards, and support to policymaking.

This spectrum of involvement with the road transport sector places EARPA members in a unique position, able to offer expertise derived from their front-line relationship with automotive products, and independence from direct vested interest in manufacture. It is hoped that the EARPA vision presented here is a useful viewpoint on future research programmes such as FP8. It is also hoped that EARPA, working together with stakeholders in the sector through the ERTRAC technology platform, can use this position to continue supporting the success of Europe in using research and technology to meet Societal Grand Challenges.
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