Challenges and Priorities for Automotive R&D

Executive Summary

Mobility and transport of people and goods is one the great achievements of mankind and securing its sustainable future is essential for European and global social and economic development. The largest part of the mobility sector, road transport, is dependent on the vehicles and services which carry the people and goods and support their efficient transport. R&D investments and the commitment of the European automotive industry are focused on topics related to the automotive key challenge areas that have been identified to be:

- Mobility and Transport
- Energy and Environment
- Safety and Security
- Affordability and Competitiveness

Automotive R&D is becoming more complex, due to the already highly advanced level of technology and to the ever increasing demands of society and the global marketplace. The focus of automotive R&D projects is on producing concrete results for the industry, which can then be further developed or exploited directly in product development. This focus on achieving R&D results should continue in future public R&D programmes. In order to address the challenges as described above, the following R&D areas are of major interest for the automobile industry:

- Mobility and Transport in Urban Areas, Extra-urban Corridors and Interfaces
- Enhanced Powertrains and Alternative Fuels
- Electrification of the Vehicle
- Safety Applications in Co-operative Systems
- Suitable Materials and Efficient Manufacturing for Automotive Applications.

It is essential to exploit all the elements of automotive R&D represented above, from the environmental and safety performance of the vehicles themselves to the interactive systems in which they operate, underpinned by optimum materials and a competitive system of production.

EUCAR will continue to work with industrial and research stakeholders, with the European Commission and other EU institutions to help define the direction for future automotive R&D, including the next Strategic Framework for Research and Innovation.

About EUCAR

EUCAR is the European Council for Automotive R&D from the major European passenger car and commercial vehicle manufacturers. EUCAR facilitates and coordinates pre-competitive research and development projects and its members participate in a wide range of collaborative European R&D programmes. The European automobile manufacturers are the largest private investors in R&D in Europe with over €26 billion investment per annum, or about 5% of turnover. EUCAR members are BMW, DAF, Daimler, Fiat, Ford of Europe, GM/Opel, Jaguar Land Rover, Porsche, PSA Peugeot Citroën, Renault, Scania, Volkswagen, Volvo Cars and AB Volvo. EUCAR is closely connected to ACEA, the European Automobile Manufacturers Association.

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Challenges and Priorities for Automotive R&D

1. Introduction

Mobility and transport of people and goods is one the great achievements of mankind and securing its sustainable future is essential for European and global social and economic development. With a population of more than 700 million and the potential for consistent economic growth, particularly in Central and Eastern Europe, mobility and transport in greater Europe over the coming years is set to rise. In this context, ensuring sustainable mobility and transport is one of the Grand Societal Challenges for Europe and should be recognised as such in EU policy.

The demand for passenger vehicles, delivery vans, trucks, and buses will continue to increase. Innovative and, above all, intelligent action is needed to contain traffic congestion, especially around the economic centres of Europe, exactly where high quality mobility and transport are required for the economy. In addition, road traffic safety, the availability of fossil fuels and the impact of the increase in transport and mobility on the environment will remain important challenges in the coming decades. Europe's economy relies on a solid and innovative industrial base and one of the prime contributors to economic output is the automotive industry.

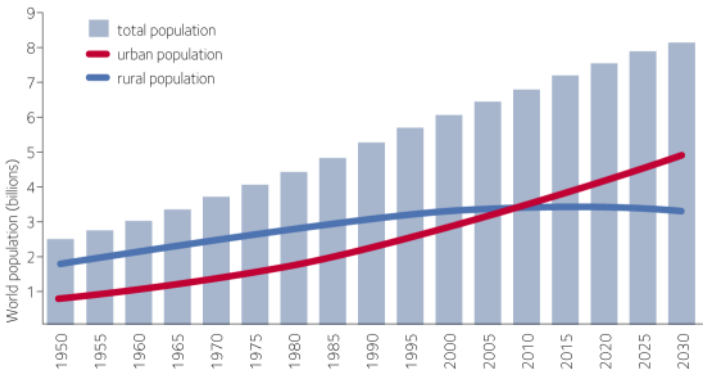

Figure 1: Urban and rural population of the world 1950-2030 (UN Population Division)

The European automotive industry strives to be the most innovative in the world and sets global standards in production and vehicle technology. New technological possibilities will continue to play an important role in addressing the enormous challenges. Identifying solutions which are truly effective and sustainable will require more, however, than just the development of cleaner engines, alternative drive concepts, better vehicle aerodynamics, lower rolling resistance, telematics solutions and advanced electronic vehicle systems.

The effective, efficient and above all lasting mobility policy for the future requires the full involvement of all relevant factors and stakeholders. A structural solution can only be found when all concerned parties and stakeholders join forces and take a new common path together.

2. Challenges for automotive R&D

The largest part of the mobility sector, road transport, is dependent on the vehicles and services which carry the people and goods and support their efficient transport. These vehicles and services must continue to provide efficiency, utility, safety and low environmental impact, thereby supporting sustainable mobility. This is the contribution of EUCAR's members, the automotive manufacturers.

The key to this contribution in the automotive sector is R&D, which drives the innovation cycle by exploiting its results to bring beneficial new technologies to the market and therefore into everyday use. The European automotive manufacturers invest €26bn per year in R&D to make this process possible and on this measure are the top innovators in European industry.

R&D investments and commitment of the European automotive industry is focused on topics related to the automotive key challenge areas that have been identified to be:

- Mobility & Transport

Mobility is the lifeblood of a modern economy. Road transport and mobility are indispensable to societal development, cultural activities and economic growth. However mobility also carries some risks: the possibility of damage to the environment, accident casualties, and delays and congestion. A key task of our time is to find sustainable solutions to meet future needs and concerns, and the industry will continue to respect its societal and environmental responsibilities in this context.

The importance of road transport to EU27 cannot be overstated. In 2008 approximately 83 % of passenger-kilometres were performed on the road (with a share of 72 % for passenger cars). Also in 2008, 73 % of tonne-kilometres inland freight was transported on the road (Source: European Commission, DG for Energy and Transport, Statistical Pocketbook 2010). The need to transport people and goods in a manner that secures the safety of all road users, the sustainability of society with respect to resources and environment and the efficiency of traffic and transport operations is of paramount concern and importance to the European automotive industry.

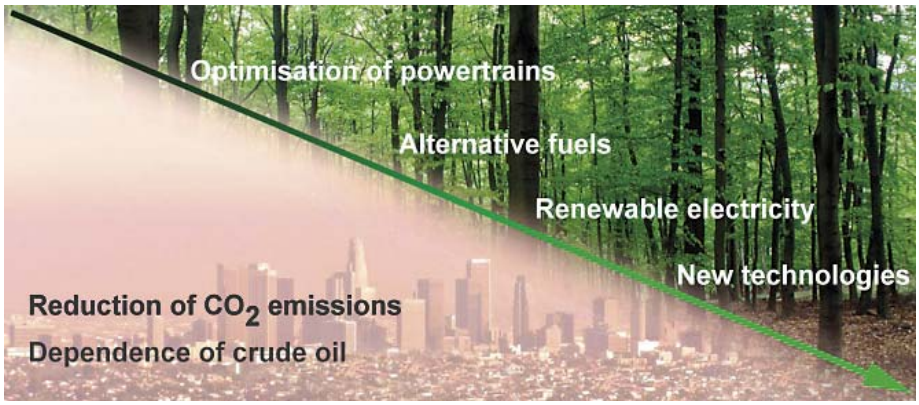

Figure 2: Challenges of the future and path to sustainable mobility

- Energy & Environment

The use of energy and other limited resources and the protection of the environment play an important role in Mobility and Transport. Whilst in the last decades the focus has been on reducing exhaust emissions and their impact on air quality (Figure 2), it is expected that in 2050, when nearly 70 % of the world's population will live in urban areas (Source: UN World Urbanisation Prospects – The 2009 Revision), R&D efforts will shift towards further reduction of CO_2 emissions, higher energy efficiency and lower noise pollution. Moreover, the secure supply of sufficient quantity and quality of fuels and other energy carriers to meet the requirements of future powertrains in order to contribute to reduced CO_2 emission is of great importance and interest to society and the automotive industry as a whole.

- Safety & Security

Road safety is an essential element of sustainability in mobility and transport. The number of casualties on Europe's roads has more than halved since 1990, while traffic volume has doubled (Source: European Commission, DG for Energy and Transport, Statistical Pocketbook 2010). The European automotive industry has contributed significantly to the safer use of roads and safer vehicles through continuous improvements in active and passive safety measures. Further improvements in road safety require an integrated approach involving all relevant actors: policy makers, infrastructure designers and engineers, road users and vehicle manufacturers.

Apart from the inherent safety risk of any road transport due to complex traffic situations, there is an increasing security threat on European roads. Drivers, vehicles and cargo run the risk of falling prey to criminal activities on the road. For commercial transport in the European Union, the total loss of value caused by theft of cargo and/or freight vehicle is estimated to be more than 8.2 billion € per year. If the loss value is related to the number of loaded trips, a value of some 6.7 € per trip results (Source: NEA, Organised Theft of Commercial Vehicles and Their Loads in the European Union, published by European Parliament, Brussels, 2007).

- Affordability & Competitiveness

Fundamentally the automotive industry is oriented towards mass-market production. In this sense the affordability and diversity of vehicles and the competitiveness of the industry are closely linked. Competitiveness in the industry's home market means offering European customers affordable products they want to own. Europe intends to stay a world-class high volume automotive design, engineering and production region and consequently safeguard existing jobs and create new employment opportunities. In particular, the development of materials suitable for automotive applications and dedicated manufacturing techniques to enable highly efficient production of vehicles and parts is essential for affordability of products and competitive road transport.

3. Priority Themes for Strategic Research in the Automotive Sector

Automotive R&D is becoming more complex, due to the already highly advanced level of technology and to the ever increasing demands of society and the global marketplace. Development of certain enabling technologies will be essential to support important future product innovations affecting the entire sector. Additionally, systems and infrastructure are becoming more important due to the fast growth and advanced nature of communication services.

The focus of automotive R&D projects is on producing concrete results for the industry, which can then be further developed or exploited directly in product development. This is an essential element of the success of EU projects in driving innovation in this sector and is the rationale for EUCAR's members to use their own resources to co-fund the R&D. This focus on achieving R&D results should continue in future public R&D programmes.

Being part of an Industry which spans the world, it is essential to take into account global trends when considering the R&D activities to be conducted in Europe. In order to address the challenges as described above, the following R&D areas are of major interest for the automobile industry:

- Mobility and Transport in Urban Areas, Extra-urban Corridors and Interfaces
- Enhanced Powertrains and Alternative Fuels
- Electrification of the Vehicle
- Safety Applications in Co-operative Systems
- Suitable Materials in Automotive Applications
- Ecological and Efficient Manufacturing of Vehicles, Components and Systems.

These R&D areas are elaborated in greater detail below:

Mobility and Transport in Urban Areas, Extra-urban Corridors and Interfaces

In Europe, the percentage of the population living in urban areas is expected to rise from 73 % in 2000 to approximately 80 % by 2030, meaning that a large and increasing proportion of the population will limit their daily travel to short / medium distances of less than 100 kilometres, often entirely within the urban environment. Road transport accounts for about 75% (EEA (2010) TERM report) of goods transport today, and continues to develop rapidly, not least because of its transport and quality characteristics. One major challenge in road transport is congestion, which will be addressed in different ways. There is for instance the concept of green corridors which can be applied in both inter-urban and urban environments. The demand for people and goods transportation will further increase over the next decades, requiring new solutions to optimise traffic fluidity and energy efficiency, hence reducing congestion and emissions.

- Advanced driving-assisted vehicles: research activities will focus on fusion of driver assistance functions both in cities and long-distance corridors to optimise overall potential, maximise comfort and safety for the driver and improve traffic flow and reduce CO_2 emissions. The driver will maintain full responsibility for the vehicle at all times.
- Energy efficient transport of people and goods with improved logistics: research will focus on the most efficient use of passenger cars, buses, light commercial vehicles and trucks for the transportation of people and goods inside urban areas, considering system aspects. Research is required to address goods logistics, optimised multi-purpose and modular goods vehicles, interface between urban and inter-urban goods transport (i.e. green corridors and goods transhipment).
- Safety of urban road transport: this research field focuses on identifying and analysing all options to increase safety within the urban environment, integrating

Figure 3: Possible design of a sustainable corridor (picture courtesy of Volvo Technology)

vehicle and infrastructure issues, and addressing the need to improve protection of the vulnerable road users.

- Traffic management: to achieve common solutions for European urban traffic, scenarios analysis should show how urban traffic could be organised in a more efficiently, e.g. traffic information, traffic guidance, "green waves", etc by sharing and optimising road infrastructure (e.g. dedicated lanes and delivery zones, bus stops, micro-goods terminals and intermodal passenger terminals).
- Vehicle specifications for green freight corridors: to improve efficiency, research will target optimised vehicle parameters for efficient operation in Green Corridors as well as vehicle modularity. Solutions will be investigated for optimal safety within green corridors as well as consideration of platooning for trucks.
- Driver aspects in green corridors: advanced human-machine interfaces to support long-distance good vehicle drivers will be necessary, in combination with driver monitoring systems. In addition, research is needed into cargo and driver security systems.
- Market implementation of innovation: field operational testing and large demonstrations are feasible for analysing the entire value chain in terms costs, benefits and customer acceptance.
- Interfaces and co-modality: interfaces and interoperability between different modes and between long-distance corridors and the local/urban network is an important research field to support efficient co-modal freight transport.

Enhanced Powertrains and Alternative Fuels

Stakeholder projections for the penetration of alternative powertrain technologies over the next decades confirm that a large proportion of newly sold light duty vehicles will continue to incorporate an internal combustion engine (ICE), a substantial proportion of which with an ICE as the sole source of propulsion. Heavy duty vehicles are expected to be largely powered by ICEs for the foreseeable future. Continued research into ICE's is therefore necessary to meet demand and support EU technology leadership.

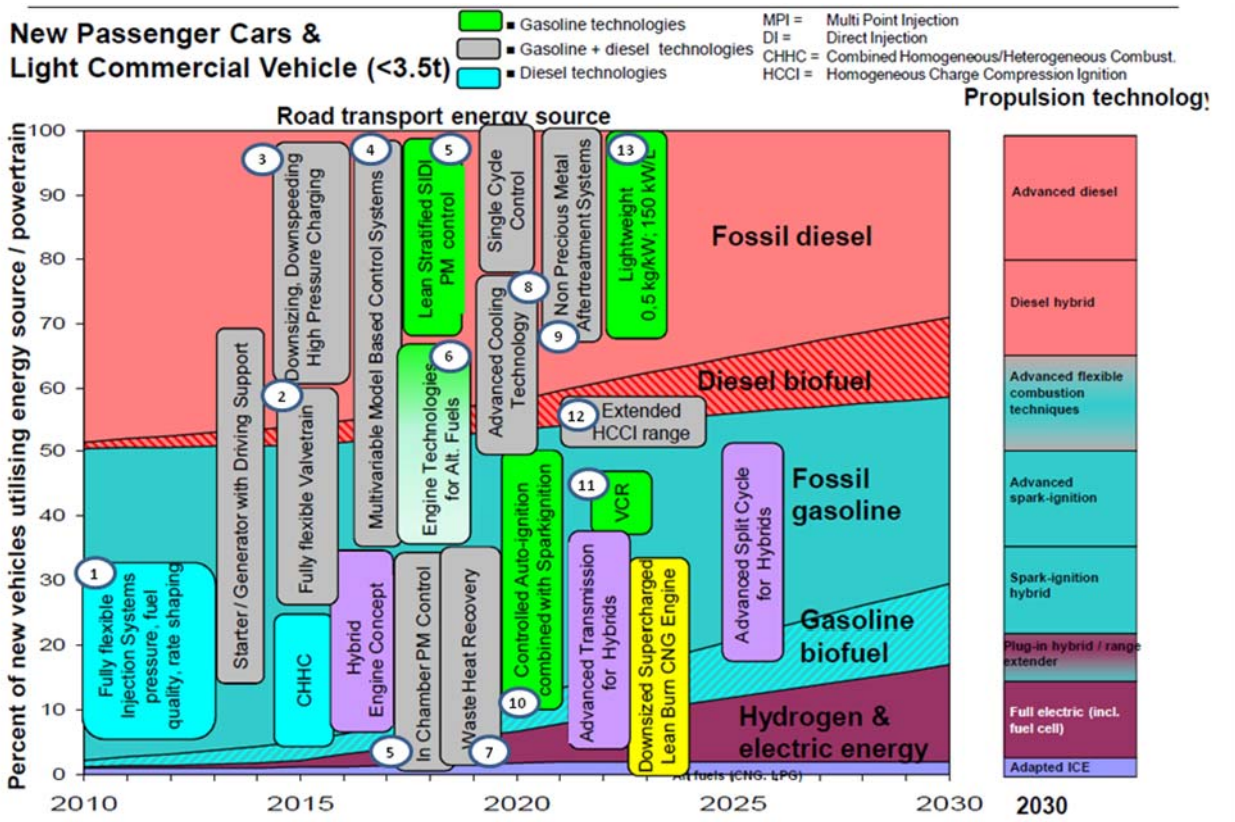

Figure 4: Main technology trends and the vision of share of engines in Europe (EUCAR Working Group Powertrain 2010)

The principal task of R&D activities on alternative fuels for vehicle manufacturers is to reduce dependency on fossil fuels by transferring to the use of primary energy sources that are renewable, secure, sufficiently abundant and more environmentally compatible. In the short-medium term this means developing and providing more energy efficient vehicles which use fuels of lower fossil carbon content. In the medium-long term, clean fuels derived from renewable primary energy sources are required which will need the development of the respective powertrain propulsion systems. In this context, potential alternative fuels include the broad range of liquid and gaseous biofuels, as well as hydrogen and electricity from renewable sources to power electric and plug-in-hybrid vehicles.

- Research into advanced technologies for ICEs is needed: technologies include flexible injection and valve train systems, downsizing, enhanced control for efficiency and emissions, alternative fuels, waste heat recovery, cooling, after treatment, auto-ignition and HCCI, variable compression ratio, lightweight engines.
- Integration into electrified vehicles: integration of efficient and dedicated ICE into hybrid, plug-in hybrid and extended range electric vehicles.
- Scenarios for alternative fuels and strategies for their market introduction: Investigations on vehicle technologies and on smart operating models for the renewable electricity infrastructure will help catalyse the development and implementation of new solutions for electrified road transport including fuel cell vehicles.
- Preparation of specifications for alternative fuels: Quality standards and specifications concerning the development of alternative fuels need to be defined, including the impact of alternative fuels on engine performance (E10, B7+, HVO,BTL) and their effect on exhaust composition and emissions compliance.
- Optimisation of gasoline power trains with alternative fuels: in focus will be the potential for using alcohol blends, natural gas and bio-methane, hydrogen and its blends with natural gas, investigating efficiency improvement, engine adaptation with high octane blends, material compatibility.
- Optimisation of diesel power trains with alternative fuels: R&D activities should focus on renewable diesel fuels including biodiesel, Hydro treated vegetable oil (HVO), Di-methyl ether (DME) and gasoline type fuels such as E95 (95 % ethanol) as well as efficiency increase, emission reduction, increased robustness of after treatment and material compatibility.

Electrification of the Vehicle

The automotive industry must identify and provide sustainable solutions for the mobility and transport systems of the future. These solutions will be exposed to even stricter requirements than those of today concerning environmental impact and emissions. Urban areas continue to attract an increasing share of the population and a large portion of the population will typically limit their daily travel to short and medium distances of less than 100 kilometres. At the same time, a large amount of goods transport will take place in the urban areas, increasing the need for cleaner and more energy efficient distribution vehicles. Today it is widely recognised that widespread electrification of the mobility and transport systems will form an important part of the solution. Correspondingly, new concepts and technologies need to be developed to realise highly efficient electric vehicles suited for individual and public mobility and for goods distribution respectively in urban areas.

- Affordable and safe battery systems with improved performance: quantified targets for passenger car Lithium-ion battery systems are to be met for energy density, calendar and cycle life durability and costs with focus on vehicle applications, for a widespread dissemination of electric vehicles.
- Post Lithium-ion technologies: to overcome current performance hurdles it is necessary to investigate post Lithium-ion technologies, encompassing basic cell research on materials for availability at lower cost and higher energy density, considering also manufacturing issues, cell design, packaging, recycling and life-cycle aspects.
- Efficient vehicle and energy management system: R&D is required for:
    - Cost reduction and efficiency improvement for the main electric drive components (electric machines, power electronics, range extenders, charging devices).
    - Efficient solutions for electrification of vehicle auxiliaries (heating, cooling, steering, braking).
    - System architecture and integration, including novel range extender concepts. Simulation methodologies covering all electrical aspects are needed for system architecture optimisation.

- Short to mid term development of new small, lower cost and highly efficient internal combustion engines designed for optimum range extender application.

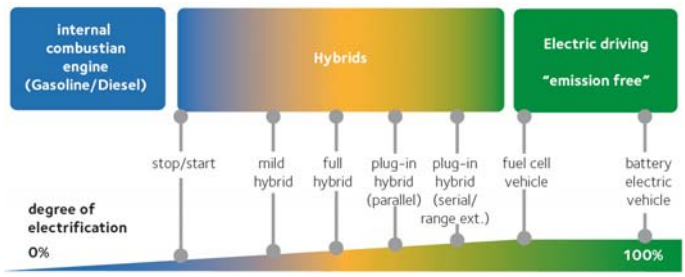

Figure 5: Electrification of the powertrain

- High voltage systems and components: high voltage (400 V) is needed, which requires further research activities regarding safety at handling, during maintenance and after collision.
- Connection to the infrastructure: this is a critical area for R&D to promote wide usage, in particular development of fast charging systems and easy to-use interfaces and dedicated information systems for charging management (localisation of free spots, invoicing, etc).
- Field tests and demonstrators: these must prove customers' acceptance and experience feedbacks, to validate the technical system including all infrastructural aspects for passenger cars, buses and light duty vehicles.
- Road map for market penetration of the electric vehicle: all economic aspects must be evaluated, including involvement of stakeholders and the analysis of the value-added chain, including concepts for electrified heavy duty commercial vehicles, with focus on hybrid technologies for commercial usage.
- Integrated safety of alternatively-powered vehicles: in depth studies are required concerning specific risks with operation and maintenance of electric or hybrid vehicles, including tests and simulations of components and the vehicles, standards and post-crash phase.

Safety Applications in Cooperative Systems

Tackling the challenges that the European Transport Safety Council has proposed (target of reducing road deaths by at least 40% between 2010 and 2020), EUCAR and CLEPA associate to anticipate the research needs in road safety. The long-term objective is realising both efficient mobility for all societal groups within the 'Vision Zero' concept, which means striving for a road transport system in which no-one is killed or severely injured anymore.

Considering the breakthrough in technological developments supporting new products and services, five research priorities are emphasized in a common document in order to ensure the achievement of the objectives by 2020.

- Design of vehicle safety in terms of integrated safety: research is required to improve and widen the accident data base, identify reliable pre-crash sensing strategies and redefine secondary safety systems, develop new sensor and integration technologies and develop advanced virtual analysis and testing methods.
- Anticipation of the safety of new vehicle concepts: research should focuses on definition of the specific safety requirements of new vehicle concepts, redefinition of primary and secondary safety systems, development of technologies to ensure crash safety for energy storage systems, advanced methods and tools for reliable modelling, experimental and virtual testing and energy management to ensure at all times the proper functioning of critical safety systems.

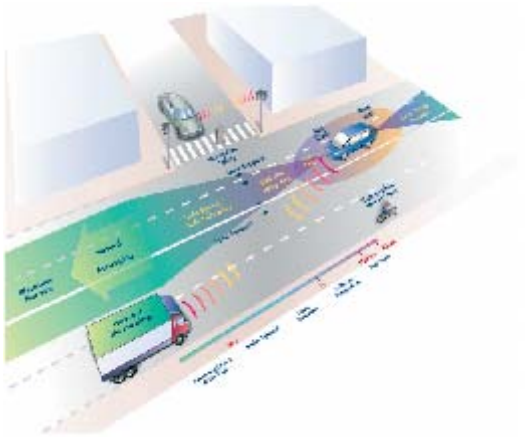

Figure 6: Cooperative systems – Vehicle-to-vehicle and vehicle-to-infrastructure communication

- Integration of communication vehicle-2-X in the safety design: research is needed into in-depth accident/ incident analysis in order to better understand the pre-crash phase, low-cost technologies for sensitive and reliable real-time vehicle-2-X technology implementation, mitigation strategies including warnings,

interventions and behaviour-based feedback, qualitative and quantitative situation modelling, improved IT security for drivers and vehicles

- Understand, modelling and improvement of driver behaviour: accident research and naturalistic driving studies are needed to develop driver behaviour models as well as research into low-cost technologies for real-time detection of driver behaviour failures and HMI[1] strategies for minimizing the distraction potential of in-vehicle information systems.
- Standardisation of methodologies for evaluating new safety systems: research is needed into advanced methods and tools for physical testing and advanced simulation tools for virtual testing, standardisation of test conditions for the tests of primary and secondary safety systems, definition of driver behaviour models for in-the-loop testing, development of field operational tests.

Suitable Materials in Automotive Applications

The affordability and competitiveness of European vehicles is of paramount importance which in the future will depend on the application of light, smart, innovative materials in addition to the new technical solutions for propulsion and safety. Consequently the development of design criteria for weight reduction plays a major role for further improvements in efficiency and lower energy consumption. Increasingly innovative, sustainable solutions can only be developed by following in an integrated approach which takes into account the entire lifecycle of the vehicle when developing intelligent design concepts and new material and process technologies. In the future, series production models will require significantly lighter solutions which offer the best balance in terms of performance, cost, weight, volume and functionality criteria.

- Improving the energy efficiency of powertrains: Since conventional powertrains will continue to play a major role in road transportation over the next decades, lowering fuel consumption by reducing friction and the weight of rotating parts will remain a vital issue for future research.
- Successful market launch of new materials for weight reduction: there is a common need for research on super-light materials meeting stringent performance, end-of-life and cost specifications, suited to efficient manufacturing processes, in particular focusing on the vehicle interiors. Relevant material domains are fibres and plastics, carbon fibres, natural/glass fibres, high strength steels and aluminium, magnesium, hybrid materials and new joining technologies suitable for mass production.

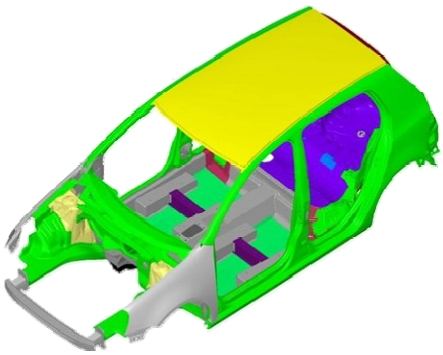

Figure 7: Innovative materials and light-weight structures are used for further improvement of the vehicle's efficiency

- Lighter and more compact seating systems: a common need exists for the development of new seating and other systems which are lighter and occupy less space. Research focuses on combining new materials and includes functional integration, manufacturing and design aspects. Simulation tools are required to enable optimisation of mechanical, thermal, electrical and additional functional properties.
- Smart acoustic insulation and damping: new technical solutions for improved acoustic comfort and reduced noise emission need to be developed for future vehicles which focus on weight reduction. New material concepts together with advanced structural construction approaches must be investigated, with aiming to reduce structure-borne sound propagation in lightweight vehicles.
- Innovative functional integration of interior components: enhanced interior comfort and improvements in perceived quality will be possible by performing collaborative research into new functions such as scratch resistance, self cleaning, self healing, smell reduction, haptic quality, optical effects and thermal properties.
- Sustainable material processing along the entire value chain: this research area focuses on the development of advanced lightweight concepts with regard to lifecycle analysis constraints and the optimal utilisation of raw materials and their re-use at the end of life.

[1] Human Machine Interface.

Ecological and Efficient Manufacturing of Vehicles, Components and Systems

Intensive efforts in the automotive industry are required to yield higher levels of energy efficiency across the entire manufacturing process. In the development of the next generation processes, ICT technologies will play a more dominant role, supporting the optimisation of the whole supply chain while increasing the flexibility of processes. Sustainable and flexible manufacturing will be fundamental to ensuring the competitiveness of the European automobile industry by setting new environmental standards and enabling products with competitive prices to be offered to a global market.

- Innovative green painting processes: to lower energy consumption during vehicle manufacture, new surface treatments, paints and processes need to be developed. Furthermore research is required to develop "one-shot" technologies for efficient production of exterior parts with high surface qualities.
- Green manufacturing of vehicles and sub-systems: significant research is required on exploitation of raw materials taking into account the entire lifecycle of the vehicle and components. The focus of activities should be on reducing energy consumption and environmental impact across the entire supply chain.
- Affordable manufacturing of green vehicles: research is required on standardisation of components and modularisation of sub-systems, exploiting the potential offered by radically different construction of new vehicles. Smart and flexible manufacturing processes need to be developed as well as systems which guarantee performance and robustness despite increased variants and highly variable volumes.
- Digital manufacturing for integrated product and process development: this research area focuses on advanced sensor applications and software for volumetric protection on machinery in order to increase the safety of manufacturing, including vision systems, the interaction of operations with the workers, collaborative robots and machinery intelligence for the operator's protection.
- Virtual engineering for performance management over the lifecycle: this research area focuses on methods and tools for the simulation of complex performance of products and processes including new materials, complex and multi-domain behaviour and physical and cognitive human interaction. Research also is needed to develop new approaches and methods for multi-domain optimisation, with respect to the product and process and including the commercial and environmental impact throughout the complete lifecycle.

Figure 8: Planning for the future in 3D with virtual manufacturing

4. Conclusion: dedicating future research programmes to the strategic research areas

The European automotive industry is a global technology leader, largely thanks to its innovative research and development. In fields where there are common interests and non-competitive advantages, the manufacturers work collaboratively so as to:

- Combine forces in a targeted way to devise strategies and solutions for future challenges,
- Develop and agree common frameworks that can serve as a basis for future standards (e.g. standards for new fuels),
- Gather the critical mass and necessary momentum for faster implementation of R&D results, and
- Share R&D costs.

EUCAR identifies future challenges and automotive R&D needs, communicates and interacts with European key stakeholders and initiates, monitors and supports R&D projects. The outcome affects innovations that are introduced to markets in the next 10 to 20 years. EUCAR involves other stakeholders, vehicle users and customers, where necessary, in order to define a common vision, goals and road maps for innovative technologies. The collaborative R&D through EUCAR provides automotive manufacturers with a means to demonstrate their commitment to pragmatic, cost-effective approaches, ensuring sustainability while preserving the economic wellbeing of Europe.

The R&D activities identified in this paper in conjunction with stimulating the implementation of R&D results provide for society's demand for mobility and transport of tomorrow and enhance the competitiveness of the

European automotive industry. They represent the current scope of EUCAR's research needs, which will naturally evolve over time. In order to implement carry out collaborative research effectively, the support of the European Union's Research Framework Programmes has proven invaluable. As investigations are currently proceeding to inform the formation of the next, Eighth Framework Programme (Community Strategy for Research & Innovation), we reiterate here EUCAR's recommendations on this subject

- Set up coherent programmes of transport R&D as an integral element of the Eighth Framework Programme.
- Include a dedicated automotive R&D initiative with a budget share consistent with the sector's contribution to the EU economy.
- Ensure that EU automotive R&D is oriented towards providing solutions for the sector's societal demands, including mobility, transport, environment, energy efficiency and competitiveness, by integrating expert input from the industry.

EUCAR will continue to work with industrial and research stakeholders, with the European Commission and other EU institutions to help define the direction for future automotive R&D, including the next Strategic Framework for Research and Innovation.