The Automotive Industry
Focus on future R&D Challenges

Urban Mobility and Transport • Alternative Fuels • Electrification of the Vehicle
Safety Applications in Co-operative Systems • Suitable Materials • Ecological and Efficient Manufacturing

EUCAR
EUROPEAN COUNCIL FOR AUTOMOTIVE R&D

Foreword

Europe's economy relies on a solid and innovative industrial base and one of the prime contributors to economic output is the Automotive industry. Together, the European vehicle manufacturers represent the largest private investor in European Research and Development (R&D), investing an average of 4 % of turnover each year on R&D activities, amounting to an annual investment of 20 billion Euros.

The strategic orientation of automotive R&D in Europe reflects the Industry's mission to integrate sustainability into all future activities directly from the outset, creating a competitive advantage for the European economy, contributing to social welfare and protecting the environment.

EUCAR, the European Council for Automotive Research and Development, identifies the R&D priorities that can be best addressed through collaborative R&D and in this context serves as an important interface between the European Vehicle Manufacturers and the European Commission. In November 2008, EUCAR published its overall strategy document (The Automotive Industry – R&D Challenges of the Future), providing a framework for a prospective automotive R&D programme and a basis for further elaboration and specification. With this new Focus document, the European Automotive Industry takes a further step forward in prioritizing selected aspects of this strategy, detailing some of the R&D efforts which are now needed to deliver the smarter, safer and greener products and services for market launch by 2020 and market penetration by 2030.

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. For the next years the following R&D areas are of major interest for the automobile industry:

- Urban Mobility and Transport
- Alternative Fuels
- Electrification of the Vehicle
- Safety Applications in Co-operative Systems
- Suitable Materials
- Ecological and Efficient Manufacturing.

Continuing to provide highly attractive and environmentally friendly products which satisfy global mobility and sustainability demand, while setting new technological standards and ensuring competitiveness and employment opportunities within a global market – these are the driving factors for European automotive R&D. By implementing these objectives **the European Automobile Industry strives to be quite simply the most innovative in the world**.

Prof. Dr. Jürgen Leohold

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Executive Summary

To develop sustainable, safe and secure products and services which are affordable within a global market, while exploiting synergies regarding pre-competitive issues, the European automotive industry has been highly active for over a decade, participating in a wide range of collaborative European research and development projects. Through EUCAR, the European automobile manufacturers have discussed and agreed on a common approach which is expressed in the EUCAR strategy (The Automotive Industry – R&D Challenges of the Future, Nov. 2008) and is based on four cornerstone research fields, namely: *Mobility and Transport*, *Energy and Environment*, *Safety and Security* and *Affordability and Competitiveness*.

Within each of these fields, the main topics for the coming years have been identified and specified in terms of the R&D activities necessary. On this basis, a range of projects conducted in collaboration will be encouraged, specifically, the main activities foreseen in each field include:

Urban Mobility and Transport

- Advanced driving-assisted vehicles
- Energy efficient transport of people and goods with improved logistics
- Safety of urban road transport
- Traffic management
- Market implementation of innovation.

Alternative Fuels

- Scenarios for alternative fuels and strategies for their market introduction
- Preparation of specifications for alternative fuels
- Optimisation of powertrains with alternative fuels
- Integrated safety of alternatively-powered vehicles.

Electrification of the Vehicle

- Affordable and safe battery systems with improved performance
- Post Lithium-ion technologies
- Efficient vehicle and energy management system
- High voltage systems and components
- Connection to the infrastructure
- Field tests and demonstrators
- Road map for market penetration of the electric vehicle.

Safety Applications in Co-operative Systems

- Connecting independent driver assistance systems in an integrated co-operative system
- Fail-safe co-operative systems
- Reliability of sensors and data acquisition through the entire chain
- Sensor data fusion and information processing in co-operative systems
- Accident prevention and collision mitigation in co-operative safety systems
- Driver feedback for safe, clean and efficient driving
- Preparation for standardisation of information and data-protocols, interfaces and evaluation
- Development and standardisation of computer modelling
- Data-collection to assist crash avoidance.

Suitable Materials

- Improving the energy efficiency of powertrains
- Successful market launch of new materials for weight reduction
- Lighter and more compact seating systems
- Smart acoustic insulation and damping
- Innovative functional integration of interior components
- Sustainable material processing along the entire value chain.

Ecological and Efficient Manufacturing

- Innovative green painting processes
- Green manufacturing of vehicles and sub-systems
- Affordable manufacturing of green vehicles
- Digital manufacturing for integrated product and process development
- Virtual engineering for product and process performance management over the whole lifecycle.

The implementation of the R&D recommendations is intended to satisfy society's demand for mobility and transport in the future while enhancing the competitiveness of the European automotive industry.

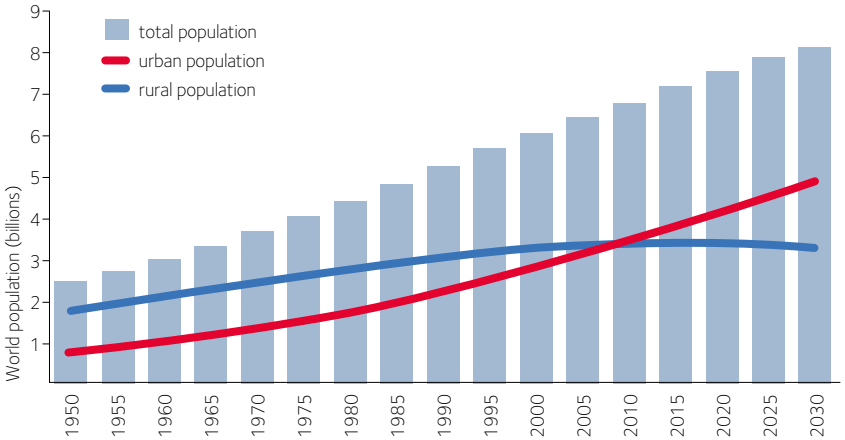

Figure 1:
Urban and rural population of the world, 1950-2030
Source: UN Population Division.

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 within entirely the urban environment. Particularly relevant to the urban mobility scenarios, 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 the negative impact on the environment. The challenge is to create a highly-efficient, harmonised urban mobility system by combining all transportation modes in the most convenient way, ensuring sustainability by providing transportation at affordable prices with significantly lower cost to the environment.

Advanced driving-assisted vehicles

Driving-assisted vehicles (e.g. Cruise Control, lane keeping functions) have already been introduced to the market and will become widely diffused over the next few years.

Based on this experience, future research activities will focus on the fusion of the various driver assistance functions in order to optimise the potential of all applications overall and maximise comfort and safety for the driver. Embedded in these research activities is also the need to qualify, quantify and to develop different levels of vehicle control and driving assistance with or without vehicle-to-vehicle and vehicle-to-infrastructure communication including the connection to the ICT-infrastructure. Dedicated research activities are required to develop appropriate, standardised driver–to-vehicle interfaces.

The long-term objective is to improve traffic flow and reduce CO_2-emissions within cities. For accurate assessment it is necessary to evaluate the impacts of advanced driving-assisted vehicles on traffic efficiency in specific situations. Primarily of interest are congested areas and intersections requiring simulation of advanced traffic scenarios in selected traffic situations. Legal and liability issues also need to be addressed in this context:

Importantly, even though advanced assistance systems are intended to reduce the complexity of the driving task in difficult traffic situations, the driver will maintain full responsibility for the vehicle at all times.

Energy efficient transport of people and goods with improved logistics

Implementing new ICT technologies for mobility and transport will provide many advantages in the future, including the opportunity to optimise the efficiency of the modes of transport which together comprise the traffic system by better utilising its full capacity. For both passenger and goods transportation, the aim is to improve traffic fluidity, reduce congestion and hence decrease CO_2-emissions. Additionally, new customer services can be developed and introduced to the market.

Regarding mobility in city centres, where large numbers of people can be moved together and public transport already offers an important option for many, further research should focus on the optimisation of multi-modal transportation systems extending to the wider urban and suburban areas which integrate a range of transportation modes including private vehicles and other solutions for individual mobility. The objective is to fully exploit the existing potential in terms of maximising the range and quality of services provided, particularly in terms of flexibility, time-efficiency and safety, while minimising traffic, congestion and the impact on the environment.

In combination with the new ICT-technologies, novel solutions will aim at achieving the full potential offered, such as new car pooling and advanced sharing systems, as well as optimising the interfaces between modes for individual mobility and public transport.

Correspondingly 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 to identify the areas of potential improvement.

System aspects concerning the linking together of vehicles, infrastructure and public transport operations must be considered, also as regards greater operational flexibility by adopting a modular data-exchange approach.

Whereas for the long distance transportation of goods, fully-loaded trains and large trucks offer advantages in terms of efficiency, as concerns the transportation of goods inside urban areas, light commercial vehicles and trucks will continue to play a fundamental role: Research is required to address specific needs to analyse and improve efficiency covering in particular:

- goods logistics,
- multi-purpose and modular vehicles optimised for the goods transport mission,
- interface between urban and inter-urban goods transport (i.e. green corridors and goods transhipment at terminals).

Safety of urban road transport

This research field focuses on identifying and analysing all options to increase safety within the urban environment, integrating vehicle and infrastructure issues, and addressing the need to improve protection of the vulnerable road users.

Figure 2:
Future assistance systems will also offer safety for vulnerable road users in urban environments.

Traffic Management

Vehicle manufactures have identified the need for a more effective approach to urban planning for improved mobility and transport also with respect to freight transport and logistics.

The automotive industry is actively participating in the definition of harmonised solutions and standards including smart ITS applications which will play a fundamental part in offering intelligent and smart multi-modal solutions for the urban mobility and transportation system of the future, the aim being to enable smooth traffic flow and easier access to cities for citizens whether they choose to use mass passenger solutions or vehicles for individual mobility.

In order to achieve common solutions for the urban traffic management in Europe, analyses of different scenarios should show how urban traffic could be organised in a more efficient way, e.g. traffic information, traffic guidance, "green waves", etc. The focus should be on sharing and optimising the use of existing road transport infrastructure, in particular through the use of dedicated lanes and delivery zones, bus stops, micro-goods terminals and intermodal passenger terminals. Achieving this goal will require the collaboration of different stakeholders within an integrated approach.

Market implementation of innovation

The implementation of new solutions and innovative urban mobility concepts require co-operation between a large number of different stakeholders. Furthermore it is essential to introduce all salient business issues already at an early stage in the R&D process in order to ensure that concepts and developments are viable to enable market introduction at a later stage.

An integrated approach is fundamental to success, requiring the collaboration of all stakeholders concerned, which is based on balancing the value chain and sharing responsibility, risks, costs and benefits appropriately among all involved.

As part of the process to identify the most appropriate route to market implementation, field operational testing and large demonstrations represent a feasible way to analyse the entire value chain in terms of relative costs on one hand and the benefits and acceptance of the customer on the other. Through practical implementation on a limited, easily-manageable scale, it is possible to identify any adjustments necessary so as to ensure a positive market implementation of the innovative solutions.

Figure 3:
Aiming towards a better quality of urban traffic – the implementation of ICT technologies offers a variety of innovative solutions.

Alternative Fuels

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.

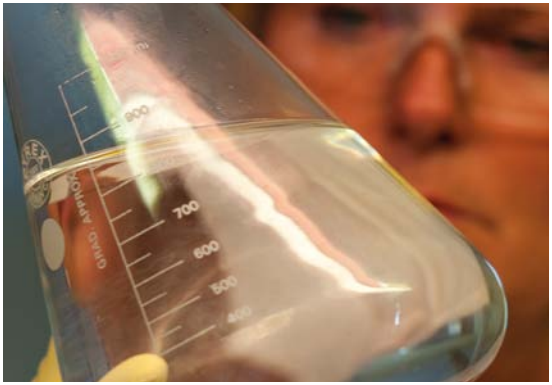

Figure 4:
Research for the ideal composition of alternative fuels.

Scenarios for alternative fuels and strategies for their market introduction

Reliable and up-to-date facts and figures are required to enable market introduction scenarios for alternative fuels to be assessed and a common strategy to be defined. The focus should be on the development of CO_2-neutral fuels from renewable energy sources, together with the vehicle technologies required for their efficient use. Besides renewable fuels, also the refining of conventional fuels requires further investigation with regard to resolving the today's imbalance of gasoline and diesel fuel demand in Europe.

The electrification of vehicles will also play a key role in the medium- to long-term, as is described subsequently. Different scenarios considering various alternative fuels need to be evaluated with respect to electricity, recognising that energy in the form of electricity from renewable sources may be produced more directly than biofuels. 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 road transport. In the long-term perspective, a further increase in renewable electricity production will also open up the potential for the new hydrogen infrastructure required by fuel cells vehicles.

Preparation of specifications of 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: degradation potentials concerning the fuels E10, B7+ Hydro treated vegetable oil / Biomass to liquid (HVO/BTL),
- The effect of alternative fuels on exhaust composition and the impact on future emission regulations.

Optimisation of powertrains for alternative fuels

One specific focus of this research area is the combustion behaviour of alternative fuels including the characterisation of the fuels themselves and evaluation of the scope for optimising the powertrains and fuels in combination.

For future gasoline engines, the potential for using alcohol blends, natural gas and biomethane, as well as hydrogen and its blends with natural gas, will be the focus of further investigations with respect to:

- Efficiency improvement,
- Adaptation of future downsized, turbocharged direct injection (DI) engines and powertrain components with high octane blends,
- Material compatibility.

For the optimisation of future diesel engines, R&D activities should focus on renewable diesel fuels including biodiesel, Hydro treated vegetable oil (HVO), Dimethylether (DME), as well as on the potential to run diesel engines using gasoline type fuels such as E95 (95 % ethanol). In addition highly important research is required to investigate in parallel the technologies for passenger car and heavy duty diesel engines considering:

- Analysis of further potential for efficiency increase by simultaneous emission reduction,
- Increased robustness of the after treatment on fuel properties,
- Material compatibility.

Standardised tools for combustion modelling of blends are essential to improve understanding and determine cost effectiveness.

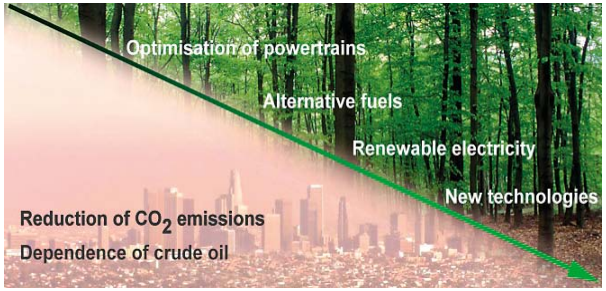

Figure 5:
Challenges of the future and the path to sustainable mobility.

Integrated safety of alternatively-powered vehicles

The rapidly increasing interest in alternative propulsion systems for vehicles urgently requires in depth studies concerning specific risks that arise with the operation and maintenance of electric or hybrid vehicles. Tests and simulations of components (e.g. batteries, tanks) as well as the analysis of the full vehicle crash behaviour must be carried out in order to improve safety-standards for vehicles with alternative propulsion systems, e.g. for the safe integration of e-drive components (packaging, cooling solutions, shutdown strategies for power electronics, etc.) and for the appropriate safety tests required.

Regarding the post-crash phase, general recommendations for rescue and emergency medical services are needed, including standards for handling e-drive vehicles following an accident.

Energy supply together with the issues concerning fossil energy resources and climate change represent major challenges being faced by society today and which are set to gain in importance over the coming years. The growing demand for mobility and energy in emerging regions make these problems even more urgent and potentially severe. 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 which already impose highly stringent limitations concerning environmental impact and emissions; clean fuels and secure energy sources, together with optimised efficiency of energy use are just a few of the boundary conditions driving the development of future vehicles.

Another fact is that the urban areas continue to attract an increasing part of the population (UN forecast is 80 % in 2030). In urban agglomerations 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.

Although a simple unique response to meet the challenges has not been identified, 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.

Without doubt, the success of current drive towards wide-ranging electrification of the transport system will depend on the coordinated co-operation of all the key stakeholders and contributors including:

- Automotive industry for developing efficient and affordable electric vehicles and components,
- Energy suppliers and distributors for deploying the needed infrastructure including charging spots and related information and communication systems,
- Authorities for the deployment and creation of suitable prerequisites for a successful market introduction of electric vehicles.

To achieve this, it is necessary to act within an integrated approach and in a consistent direction right from the outset, based on today's technologies in the short term but projected towards the longer term when adapted. New technologies will enable the electric vehicle to become affordable to private consumers and therefore achieve full market penetration in urban regions. Standards and common interfaces (e.g. vehicle-to-infrastructure charging including exchange of relevant data between vehicle and infrastructure) need to be agreed upon rapidly for Europe as a whole to avoid a fragmented pattern of local competing solutions giving rise to compatibility issues. This represents a unique opportunity for the European industry to establish a position of global leadership in electric vehicles and related transport systems. In this scenario, to achieve this potential, the battery technology at cell, module and system level plays a key role while transversally impacting other application fields.

Regarding range, affordability and interior space provided by the vehicle, the first electric vehicles on the market satisfy customer expectations only to a very limited extent. Considering the low vehicle volumes forecast initially, necessarily the early electric vehicles correspond to derivations of existing vehicles, using current "electric" technologies that have been adapted from other applications, even from outside the automotive market, leading to expensive solutions with limited durability and insufficient performance. Hence, in order to achieve a large scale replacement by electric vehicles over conventional vehicles, it is necessary to support an accelerated evolution of electrification technologies. For future electric vehicles, increasingly dedicated design solutions for the vehicle will be introduced progressively in order to enable optimised component technologies to be exploited fully.

The intelligent integration into the existing urban transport infrastructure, such as the application of intelligent ICT solutions to enable optimised traffic management and intermodality between different types of transport solutions, will be essential to overcome some of the current shortcomings of the electric vehicle.

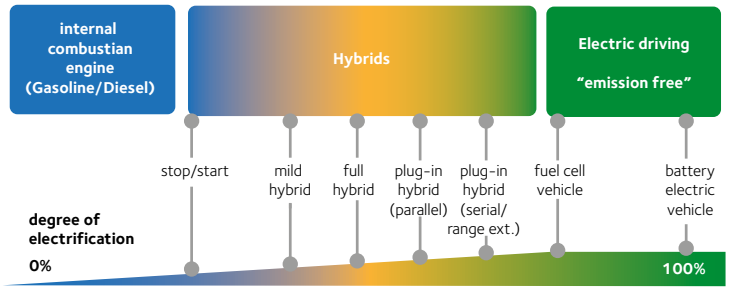

Figure 6:
Electrification of the powertrain.

The following R&D activities have been identified in this area:

Affordable and safe battery systems with improved performance

Market introduction and convenient use of vehicles with an electric powertrain depend mainly on the costs and performance of these vehicles. Safe operation certainly has to be secured for all automobile applications. The key component for both performance and cost of an electric vehicle is the energy storage system. Today it is expected that the energy storage system over the near term will be a lithium-based battery system.

It has to be taken into account that a battery system includes, besides the battery cells, components for interconnections and packaging as well as electrical and thermal management equipment. All these additional components have a significant influence on the overall volume, weight and cost of a battery system.

Even though significant progress has already been made in terms of the specific energy content of modern batteries, i.e. energy density with respect to the volume and weight, it still remains about two orders of magnitude lower than that of conventional fuels used in combustion engines. This fact alone represents one of the principal challenges for fully electric mobility in general also because a wide range of other factors are influenced as a direct consequence including cost and operational usability. For this reason, the focus for the deployment of the Battery Electric Vehicle (BEV) is on urban and near-urban transportation, at least for the foreseeable future. The required range of BEV under everyday conditions (including energy for comfort functions such as heating, air conditioning, etc.) will be 150 km (250 km under ideal conditions) in 2015. The research target is to provide a range of approx. 200 km (300 km under ideal conditions) in 2020.

The corresponding quantified targets that need to be met for passenger car Lithium-ion battery systems are:

- Performance:
  Energy density has to be improved at least to 180 Wh/kg in 2020 (130 Wh/kg in 2015). Current technologies achieve below 100 Wh/kg.
- Durability:
  Calendar and cycle life targets have to meet the expected lifetime for the vehicle. Batteries must last at least 15 years lifetime or 5500 deep charge/discharge cycles by 2020 (4000 charge cycles in 2015 with 10 years life-time) in order to operate the vehicle without replacement over vehicle life.
- Costs:
  A target of less than 140 €/kWh has to be achieved in 2020 (less than 215 €/kWh in 2015) for a widespread dissemination of electric vehicles.

Post Lithium-ion technologies

To be able to overcome the performance hurdles of Lithium-ion technologies in the long term, already today it is necessary to investigate post Lithium-ion technologies for further improvement of the overall performance of electric-powered vehicles. This research must encompass basic cell research on materials in order to ensure availability with lower costs and higher energy density, considering also manufacturing issues, cell design and packaging, and recycling and life-cycle aspects according to the operational requirements and usage of the vehicles.

Efficient vehicle and energy management system

Today, the internal combustion engine powers the electric systems for safety and comfort features, including the braking force booster, power steering, air conditioning and heating. Instead, in the fully electric vehicle, the energy for these systems must also be supplied by the battery. In addition, the battery has to be thermally managed to avoid damage and premature aging. Moreover, in order to limit the negative impact on the range of the electric vehicle, it is essential to not only minimise the energy consumption of the on-board safety and comfort systems, but also investigate the full potential of energy recuperation and harvesting from the different sub-systems also with regard to that currently dissipated in vibrations and thermal effects. From the customer's perspective, apart from the costs, the main difference today between a vehicle with an internal combustion engine and a full electric powertrain is the significantly lower autonomy of the electric vehicle together with the much longer recharging vs. refuelling time. Correspondingly, in order to avoid over-dimensioning the battery capacity and added vehicle costs, R&D is required for:

- Cost reduction and efficiency improvement for the electric powertrain concerning main drive components e.g. electric machines, power electronics and those specific to the electric vehicle such as range extenders and charging devices.
- Efficient solutions for electrification of vehicle auxiliaries, for example for heating (which today uses waste heat from the combustion process), cooling, steering and integrated passive and regenerative braking,
- System architecture (e.g. redundant concepts in order to ensure the function of safety critical systems) and integration, including novel range extender concepts. Simulation methodologies covering all electrical aspects are requested for the optimisation of the system architecture.

Specifically focused R&D is required in the short to mid term on the development of new small, lower cost and highly efficient internal combustion engines designed considering not only the constraints but also the advantages of the range extender application usage. This will be necessary in order to reach the extremely ambitious targets in terms of noxious, CO_2 and noise emissions.

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.

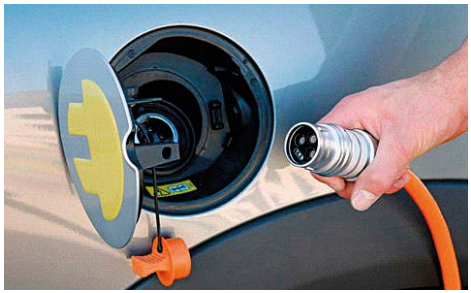

Figure 7:
Charging the electric vehicle.

Connection to the infrastructure

One of the most critical areas for R&D in terms of promoting the wide usage of electric vehicles regards the connection of the electric vehicles to the infrastructure, particularly as concerns:

- Charging: development of fast charging systems, easy-to-use interface to infrastructure,
- Dedicated information system for charging management: localisation of free spots, invoicing, etc.

In addition to the specific R&D topics which are related to the vehicle, its components and its interface to the grid, also with respect to the usage of high voltage, activities are necessary for the definition of a road-map for market creation and penetration. Required are field tests and demonstrations in order to acquire experience and feedback from the initial customers, facilitating the design of the next generation of electric vehicles, optimised for electric mobility.

Field tests and demonstrators

Field tests and demonstrations must prove customers' acceptance and experience feedbacks. This is needed to validate the technical system including all infrastructural aspects. Passenger cars, buses and light duty vehicles should participate in such field testing.

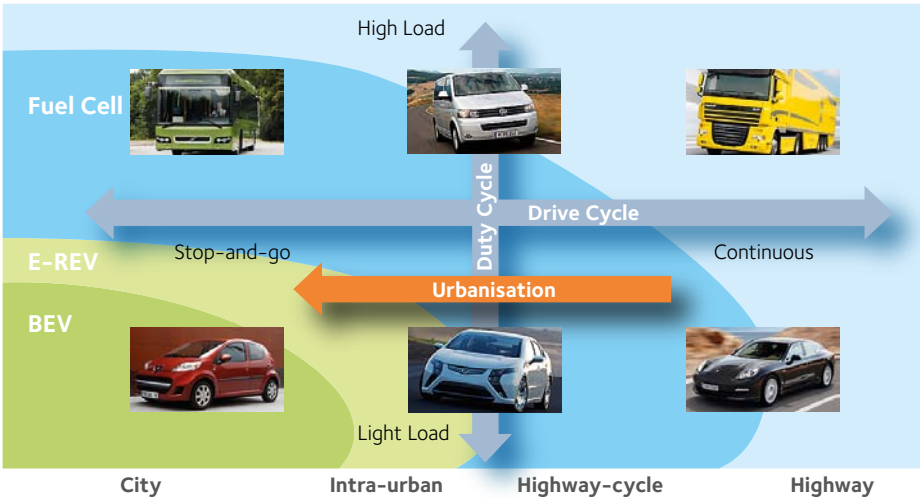

Figure 8:
Application map for Battery (BEV), Extended-Range (E/REV) and Fuel Cell Electric Vehicle

Road map for market introduction of the electric vehicle

In order to introduce electric vehicles and the necessary infrastructure successfully to the market, all economic aspects must be evaluated, including the involvement of stakeholders (e.g. energy suppliers, car manufacturers, infrastructure providers and road authorities, ICT sector and customers) and the analysis of the value-added chain. This is necessary in order to define an operating model also including the aspect of residual value of the vehicle at the end of its life. Concepts to be investigated should also include electrified heavy duty commercial vehicles, but with a stronger focus on hybrid technologies in order to ensure commercial usage, bearing in mind also that many of the technological solutions may find application to different types of vehicles with electric powertrains including plug-in-hybrids and fuel cell vehicles.

Safety Applications in Co-operative Systems

To enable the step to the next level of road safety, an integrated approach is needed to implement new Information and Communication technologies (ICT) and thus merge co-operation between the driver, vehicle and infrastructure. These co-operative systems intend to deliver valuable information regarding the surrounding traffic situation to the driver and provide additional, direct support in complex and difficult driving environments.

In the future, Intelligent Transport Systems (ITS) should interface with in-vehicle safety systems in order to exchange information and reinforce operational strategies for the optimisation of safety.

Several actions are needed and different requirements have to be addressed to ensure progress: Apart from the essential technical development required, the reliability of the chain of information capture and processing, and the standardisation of data, interfaces and procedures (including their detailed evaluation) need to be investigated. Furthermore implementation and validation depend on the development of tools such as numerical modelling and naturalistic driving studies.

Furthermore a new set of challenges should be taken into account such as the implementation and penetration of co-operative systems into the market and the integration of safety aspects of alternatively-powered vehicles.

Connecting independent driver assistance systems into an integrated co-operative system

The increasing concentration of traffic in more complex driving environments makes it necessary to provide the driver with only essential information and offer assistance in difficult situations.

For passenger cars, the long term research objective remains the promotion of safe and efficient driving by providing functions where the driver is still in the loop.

For commercial vehicles, research is required regarding safe convoying concepts and platooning, including all necessary standardisation issues as a next step towards advanced driver-assisted driving. On highways, platooning concepts for heavy duty vehicles can reduce the risk of accidents in specific situations, while offering additional benefits in terms of lower aerodynamic resistance which enables fuel consumption and CO_2-emissions to be reduced. Within the urban context, especially in delivery zones, on light commercial vehicles advanced driver-assisting systems can increase the safety of other vulnerable road users by supporting the driver in very complex traffic situations, including the automatic detection of pedestrians and obstacles in the path of the vehicle.

These systems will provide a high-level of support for the driving tasks, essentially offering recommendations to the driver who will continue to maintain full responsibility and over-riding control of the vehicle, particularly as concerns steering, acceleration and deceleration.

Fail-safe co-operative systems

Co-operative systems are designed to improve both safety and traffic efficiency. For future generations of such solutions, exploiting the potential for driving intervention under the control of the driver, total reliability will also be indispensable. However, since those co-operative systems will not be introduced into the market in the near future, the need to make them fail-safe can be regarded as a longer-term objective.

Reliability of sensors and data acquisition through the entire chain

Research is required to ensure the reliability of sensors and data throughout the entire data processing chain, the ultimate objective being to achieve standardised and quantitative validation of sensor and communication data.

Sensor data fusion and information processing in co-operative systems

As large amounts of information are collected through co-operative systems and different sensors of the vehicle, one key objective is to enhance the description of the surrounding environment on the basis of distributed and flexible sensor networks. Particularly of relevance is the identifications of road surfaces, visibility and traffic conditions.

Another key objective is the combination and processing of information from different sensors and co-operative systems in order to facilitate its presentation and usability by drivers through safe and ergonomic Human Machine Interface (HMI) integration.

Accident prevention and collision mitigation in co-operative safety-systems

Research is required in the fields of integrated braking and steering for collision mitigation or potentially avoidance (including avoidance of pedestrian collision) and integration of all actions from driver warning to system-initiated intervention, the aim being improved safety while increasing vehicle design freedom.

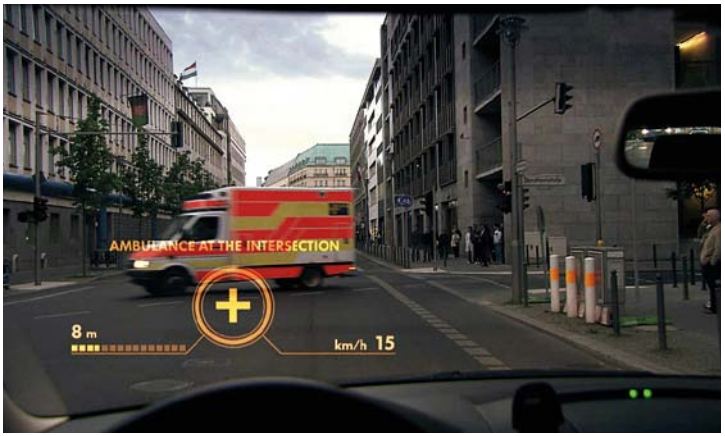

Figure 9:
The implementation of ICT-technologies will provide a higher level of transparency on the driving situation ahead and thus assists the driver in complex traffic situations.

Driver feedback for safe, clean and efficient driving

The challenge consists in defining and combining the relevant driving and driver parameters in order to adapt feed-back to all driving conditions. The amount of feedback and information given to the driver will depend on the traffic and environment conditions. All data that is delivered from internal and external sources to the vehicle needs to be assessed in terms of immediate necessity for the driver, integrated and processed. The feedback will be adapted to the driver in real time, whereas information will be provided to improve the driving style successively when the trip has been completed. The aim of driver feedback is to improve the safety and efficiency, hence reducing CO_2 emissions.

Preparation for standardisation of information, data-protocols, interfaces and evaluation

Currently the standardisation of vehicle-to-vehicle and vehicle-to-infrastructure communication is the topic of considerable interest and activity in Europe. Through efforts in the Car-2-Car Communication Consortium and European Telecommunications Standards Institute (ETSI), a range of aspects are being addressed: frequency band usage, ITS architecture, data protocols, robust channel access methods, data security, etc. Standardisation in these areas will pave the way for the successful launch of future co-operative systems, and EUCAR will continue to contribute to this important effort by participating in the activities of relevant Working Groups, in addition to supporting those members active in standardisation forums.

The aim is to develop a reliable and secure exchange of information through standardisation of open and semi-open application platforms. The need for robust interfacing of services offered by external service providers will lead to new research topics developed on the basis of results from previous and ongoing projects in this area (Global System Telematics, Co-operative Vehicle-Infrastructure Systems etc.). Moreover, for the development of advanced co-operative safety systems, it is vital that evaluations use a standard basis. Correspondingly, appropriate evaluation criteria need to be identified and validated which in turn requires further development of testing and simulation methods.

Development and standardisation of computer modelling

The research efforts to develop and standardise human body modelling must continue to completion, being of fundamental importance for the development and standardisation of advanced protection systems by enhancing computer simulation for virtual crash-tests.

From the perspective of integrated safety, research is particularly needed in terms of driver behaviour modelling.

Moreover, the effort to develop simulation tools including macroscopic and microscopic aspects will enable the a-priori validation of potential benefits offered by Advanced Driver Assistance Systems (ADAS). Today different elements are already available, but the interfaces require further development. These tools will enable time to be saved while serving to integrate the contributions of the different stakeholders involved including

- academia (focusing, for example, on driver modelling),
- public authorities (involved in societal impact assessments),
- vehicle manufacturers and
- suppliers (defining system specifications),
- and those concerned with the maintenance and upgrading of these simulation tools.

Data-collection to assist crash avoidance

A lack of detailed information still exists regarding the pre-collision phase of accidents which is required for the development of primary safety systems. Only limited information derived from reconstruction of accidents and event data recorders is available, and the processes and factors that have an influence on the change from a normal driving situation to a critical situation remain largely unknown. Correspondingly naturalistic driving studies are needed to deliver the necessary data in order to fill this knowledge gap.

Suitable Materials

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 automobile companies to perform research on super-light materials for many of the systems and components on the vehicle which meet stringent performance and end-of-life specifications and cost requirements, and which are suited to efficient manufacturing processes.

In many cases the market position of a single vehicle manufacturer is not sufficiently strong to influence the supply industry to initiate the scale of research activities currently required. Therefore in order to strengthen the market position of individual automobile companies, joint collaborative activities are essential in this area. Holistic research activities should include analysis and simulation across the entire value chain from the raw materials to the final vehicle product while focusing specifically on recycling issues and lifecycle-analysis. From this perspective, required in particular is intensive research which focuses on the vehicle interiors.

Relevant material domains are:

- fibres and plastics: carbon fibres, natural/glass fibres
- high strength steels and aluminium
- magnesium technologies
- hybrid materials
- new joining technologies suitable for mass production.

Lighter and more compact seating systems

A common need exists for the development of new seating systems and other interior components and sub-systems which are lighter and occupy less space within the vehicle compartment taking into account present and future safety standards. Research into new solutions must focus on combining new materials and include functional integration, manufacturing and design aspects. Additionally, simulation tools need to be developed in order to enable optimisation of mechanical, thermal, electrical and additional functional properties with respect to the lightweight materials used and the adaptation of manufacturing technologies.

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 with respect to conventional damping and sound insulation. New material concepts (e.g. hybrid polymer systems and nanostructures) together with advanced structural construction approaches must be investigated, with special focus on concepts using smart materials and solutions aiming to reduce structure-borne sound propagation in lightweight vehicles while exploiting the potential offered through increased electrification of the vehicle.

Innovative functional integration of interior components

Enhanced interior comfort and further improvements in perceived quality will be possible by performing collaborative research into integrating new functions such as

- scratch resistance,
- self cleaning,
- self healing,
- smell reduction,
- haptic quality,

Figure 10:
Innovative materials and light-weight-structures are used for further improvement of the vehicle's efficiency.

- optical effects (e.g. interior lighting) and
- thermal properties (e.g. Infrared absorption and reflection, thermal capacity etc.)

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.

Ecological and Efficient Manufacturing

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

In order to lower the energy consumption during the manufacturing of vehicles, new surface treatments and paints, together with their respective processes, need to be developed. Furthermore research is required to develop innovative "one-shot" technologies for efficient production of exterior parts with high surface qualities.

Green manufacturing of vehicles and sub-systems

Significant research is required in order to analyse in depth the full potential for exploitation of raw materials taking into account the entire lifecycle of the vehicle and its constituent components.

The focus of activities should be on decreasing the energy consumption across the entire supply chain and on reducing the total environmental impact. From this standpoint, all the critical processes concerning the exploitation, production and transformation of materials need to be reviewed.

The modelling of transformation processes concerns many aspects of relevance including

- material extraction,
- foundry or processing,
- forming, treating,
- finishing,
- assembly and disassembly,
- scrapping,
- recycling and
- heat generation, neutralisation, graving and
- logistics.

Affordable manufacturing of green vehicles

Regarding the next generation of vehicles specifically designed to provide significantly reduced environmental impact, also the effectiveness of the manufacturing processes needs to be verified regarding costs, time and quality. Research is required which focuses on the standardisation of components and the modularisation of sub-systems, exploiting the potential offered by the new vehicles which may be radically different also in terms of construction from conventional vehicles and enable further improvement of the respective assembly processes. Specific attention is required for electric vehicles, and the new issues which may arise regarding their constituent components and sub-systems including batteries.

In order to reduce costs to a minimum, smart and flexible manufacturing processes need to be identified and developed. Required are manufacturing systems which guarantee performance and robustness despite the demand for increasing product variants and highly variable production volumes. In the future, new factory-oriented frameworks are needed for automation and robotics in order to create open, modular and re-configurable control platforms including a range of different machines and equipment.

Figure 11:
Virtual reality demonstration.

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. In particular this includes vision systems, the interaction of operations with the workers, collaborative robots and machinery intelligence for the operator's protection. Via easy-to-use simulation tools including novel software-features, the factories of the future including buildings, resources and virtual products need to be modelled and represented virtually while taking into account the optimisation of the lifecycle already during the vehicle development phase. In detail this also includes the standard automatic generation of machinery programs and their virtual validation considering the interaction with the real machine control.

Research on virtual engineering covers the broad area of tools and environments in order to set up multi-domain, multidimensional manufacturing factories and processes.

Virtual engineering for product and process performance management over the whole lifecycle

This research area focuses on methods and tools for the simulation of new and complex performances of products and processes including new and complex materials, complex and multi-domain behaviour as well as physical and cognitive human interaction. Associated with these simulation capabilities, research 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.

This approach encompasses a series of challenging research topics of high relevance and common interest to the vehicle manufacturers and the supply chain:

- New open, flexible architectures to integrate product and process representation, data and process management, design and evaluation, refinement tools, factory and service feedback.
- Holistic, evolutionary product representations based on semantics, ontology and embedded rules,
- Co-located and remote collaboration technologies and systems, focused on low cost, open solutions preserving security and IPR management,
- Cost-effective, unobtrusive, high immersion rate of virtual reality and augmented reality systems for virtual product engineering and user-in-the-loop testing.
- Real time architectures and middleware are able to seamlessly link product representations and simulation and virtual reality environments.

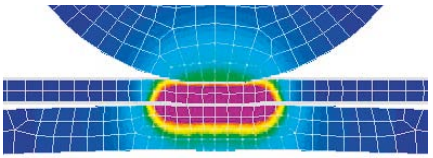

Figure 12:
Simulation of resistant spot welding (RP).

Collaborative R&D – Role of EUCAR

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.

European trans-national collaborative R&D efforts are amongst others carried out under the auspices of the European Council for Automotive Research and Development (EUCAR), focusing on pre-competitive issues of mutual interest. The automotive manufacturers founded EUCAR in 1994 as a platform and body to enable and support collaborative R&D in Europe.

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 well-being of Europe.

The direction of the collaborative R&D projects underlines the paramount importance EUCAR attaches to ensuring that solutions developed today prove to be sustainable in the long term, especially for the generations that will become the vehicle users of tomorrow. Correspondingly education and training, regarding vehicle use and driving styles, for example, which influence traffic safety, fuel usage, and the environment, will form an increasingly important aspect of automotive manufacturers' efforts. The industry will help to promote the culture of safe and efficient driving while enhancing awareness of society regarding the new technologies available and under development through the collaborative R&D activities supported by EUCAR.

These R&D activities 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.

Table of Figures

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