R&D Priorities for the Greening of Vehicles and Road Transport

A contribution by CLEPA and EUCAR
to the European Green Car Initiative
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This document expresses R&D needs for developing and evolving towards greener vehicles and road transport systems. It represents the view of the European Automotive Manufactures and Suppliers. The document is one result of the collaboration between EUCAR and CLEPA.

1. Executive summary

This document expresses major R&D priorities for the greening of vehicles and road transport as seen by the European automotive manufacturers and suppliers. The purpose of this document is for the automotive industry itself to harmonise the R&D directions and priorities, to communicate these to relevant authorities and bodies at national and EU level and to other key partners. In particular this document is intended as an input to the European Green Car Initiative (EGCI). It should be understood that its scope is therefore adapted and narrowed to the domain of the EGCI, and it does not claim to cover the broad spectrum of automotive and transport R&D.
The R&D domain in this document is structured into four major areas described below.

Mobility and Transport

The challenge is the high and still increasing demand for mobility and transport of people and goods, in urban and rural regions. R&D should address these issues by exploring:

- Information and Communication Technologies and Intelligent Transport Systems for traffic and transport management, for the single vehicle and its route planning,
- Increased use of all modes of transports, their interfaces, and efficiencies,
- Novel concepts for individual and collective mobility and transport.

Energy and Environment

The principal task is to transfer from fossil energy dependency, and its environmental impact, to primary energy sources that are renewable, secure, sufficient, and environmentally compatible. R&D should explore:

- Alternative primary energies, their related fuels and drivetrains,
- The electrification of the vehicles and the road transport system as a whole,
- Lightweight structures and new vehicle concepts for high-energy efficiency.

Safety

The introduction of new types of vehicles based on low weight materials and designs, alternative fuelled and electric drivetrains, etc. requires also adapting the safety features of these vehicles to ensure, at least, zero degradation of the safety of vehicles. R&D should focus on:

- Exploring how passive/active/ICT systems should be adapted and extended to the future vehicle concepts,
- Studying the safety characteristics offered by new vehicle types, e.g. electric drivetrain,
- Development of cooperative systems for efficiency and safety, based on communication between vehicles and infrastructure.

Affordability and Competitiveness

Green vehicles and green road transport are achievable only if there are competitive manufacturers and service providers that offer them at an affordable price level to the user. Challenges for the automotive industry, that R&D should address, are

- Availability and use of raw and rare materials,
- Efficiency and energy use in the production and manufacturing processes,
- Handling of low weight, mixed materials and alternative drivetrain,
- Flexible production and manufacturing for small series and tailored vehicles,
- Use of virtual tools and ICT from order to delivery, service and maintenances.

2. Introduction and purpose of this document

Challenges in terms of CO_2 emissions together with customer demands for enhanced energy efficiency will encourage the automotive industry to move towards green vehicles.
To achieve global leadership in this domain, and to shape a consistent and efficient approach towards the future traffic and transport systems considerable efforts in pre-competitive and cooperative research, innovation and deployment are inevitable.
This inspired the European Council for Automotive R&D (EUCAR) and the European Association of Automotive Suppliers (CLEPA) to further strengthen and enhance their collaboration.

This document is one result of that collaboration between EUCAR and CLEPA. The intention is to clarify and communicate the automotive and road transport R&D needs as seen by the European Automotive Industry for their engagement and contribution to greening of the vehicle and the road transport system.

For short-term actions, this document will be used to point at high priority topics that fit under the R&D part of the EU Commission's European Green Car Initiative (EGCI). CLEPA and EUCAR have been in discussion and collaboration for many years, and the EGCI has strengthened and shown the relevance of this manufacturers-suppliers effort in finding common strategies and sharing R&D resources to reach solutions for the present and future challenges.

3. Outline of major R&D areas

Future automotive and road transport R&D should lead to a traffic and transport system that provides efficient mobility and transport of people and goods, consumes energy and resources in a responsible way, improves safety and security, and is accessible, attractive and affordable for the ordinary citizen.

In this perspective we identify four major areas of challenges and R&D needs:

- Mobility and Transport,
- Energy and Environment,
- Safety,
- Affordability and Competitiveness.

All of these areas are equally important and none of them can be considered independent from the others. The following pages outline the challenges and R&D needs for these four areas.

The European automotive manufacturers and suppliers acknowledge that they have key roles as contributors in research, development, innovations, products and services in these four areas. And they are dedicated to actively fulfil these roles.

4. Mobility and Transport

Challenge

Mobility and Transport form a very complex system where many actors and transport modes are interconnected, dependent and sometimes in conflict and competition.

In the future the automotive industry expects:

- Continued increased demand for mobility;
- Further concentration of the population into urban regions causing ever increasing traffic density and congestion;
- Continued consumption of energy for traffic and transport;
- Continued increased demand for goods transport.

Objective

Automotive R&D aims to contribute to an accessible, safe, diverse and affordable transport system for people and goods that works in an energy efficient way and is able to cope with today's and tomorrow's public and private collective and individual mobility demands.

Major R&D Needs

- Intelligent Transport Systems (ITS) with innovative components and Information and Communication Technologies (ICT) solutions for individual planning of the trip and overall efficient traffic management.
- Efficient traffic management and reliable real-time traffic information:
  - Reliable, real-time multi-modal travel and traffic management and information that can be accessed anytime and anywhere;
  - Development of open ITS frameworks that allow for system compatibility and interoperability leading to efficient area-wide traffic management within dense urban areas, on roads with highly fluctuating traffic intensity, and across jurisdictional boundaries to interurban roads and adjacent urban areas;
  - ITS applications recommending routes for high fuel efficiency and low environmental impact;
  - Assessment of impact of ITS on greenhouse gas emissions.
- Efficient use of all modes of transport through improved interfacing of transport hubs:
  - Improved interfacing of transport infrastructures and services for different transport modes (road, rail, waterborne and air) and increased accessibility to improve co-modality;
  - Multi-modal travel advice adapting to user preferences and to considerations of traffic/energy efficiency and environmental impact.
- Energy efficient transport of goods, freight distribution and improved logistics:
  - Development of complementary modularisation principles and architectures for goods carriers and vehicles in order to facilitate an improved transport and energy efficiency;

    - Developments of open ITS frameworks for goods logistic systems and cost and time databases for different modes.
- Development of new mobility concepts for a safe, sustainable and convenient individual and collective transport of people.
- Assisted and partially autonomous driving improving the efficiency of vehicles:
    - For different vehicle types (buses / cars / trucks) and drivetrain modes (conventional, hybrid, electric);
    - In several urban topologies (corridors, cross-roads, roundabouts, city centres, etc.).
- The Green Vehicle in the Transport System
    - Information, systems for interfacing / exchange between modes or types of clean vehicles;
    - Demand management information and control;
    - Interfaces among various levels of “environment zones” (traffic and network information, management systems);
    - Improved facilities for the safe and secure transport of goods on road networks and inter-modal transport systems including data-security, vehicle tracking and monitoring, safe resting places and appropriate routing, authentication of users for security in cases in crime;
    - Energy supply and security systems (information related to energy needs).
- Test and pilot demonstrations.

5. Energy and Environment

Challenge

The shrinking availability of fossil energy requires, in the short to medium term, strongly increasing the energy efficiency of vehicles and of the traffic and transport system as a whole.

For the long term, road transport will reduce its dependency on, and finally abandon, fossil and other non-renewable sources of primary energy.

At the same time, the protection of the environment is calling for further reductions of exhaust gas emission (particulate, CO_2, …).

Objective

The objective for the automotive industry is in the short-medium term to reduce the dependence on fossil fuels through more energy efficient vehicles.

In the medium-long term clean fuels based on renewable primary energy sources have to be used and corresponding powertrain propulsion systems need to be provided.

Major R&D Needs

- Electrification of the vehicle:
  Due to its zero local and potentially minor greenhouse gas emissions, electric propulsion and drive trains combining alternative technologies (hybrid, plug-in, electric drive, hydrogen and fuel cell) will play a key role in reducing the impact of transport on energy consumption, climate and environment. Boosting the pure electric mileage requires innovative system integration, a tuned interplay of power

sources, drives and auxiliaries, and an electrical architecture aiming at reliability, innovation and competitiveness by defined standards, modules and interfaces for the transfer of energy and data. Moreover, a focus has to be put on safe, robust and cost-efficient batteries and on the connection to the grid. This leads to needs for research in the following fields:

- Energy storage systems: two major technology paths should be followed:
  Battery systems for vehicle applications based on further improvement of Lithium Ion-based battery cell chemistry and technology;
  Basic research on new open cell systems technology (post Lithium-ion battery cells) for highest energy density focussing on electrochemistry of battery cells and storage capacitors (packaging, crashworthiness, durability, reliability, adoption to different vehicle concepts) with an appropriate level of safety;
- New vehicle concepts required for electric propulsion technologies, e.g. using in-wheel motors;
- Solution for electric vehicle integration issues:
  Energy management based on models of the vehicle power architecture, thermal management for efficiency improvements and long lifetime of components and for energy efficiency of climate controls;
- Functional architecture, position and standardization of interfaces for power and data, distributed x-by-wire systems and design rules for the plug-in electrified vehicle and its structural architecture matching new requirements and fail-safe aspects;
- Key components for hybrid, electrical drive and fuel cell systems:
  Advanced electric motors, brakes, suspensions and recuperation technologies, improved power electronics (inverters, converters), mechanical or thermal energy recovery systems, components for the management of power flow, battery management systems (including development of load cycles for lifetime estimations, and operation strategies for combined storage), range extenders, and interfaces for power and data communication inside the vehicle;
- Efficiency improvements of all auxiliaries and sub-systems which consume electrical energy in the vehicle including, for example, alternative solutions for heating and air-conditioning;
- Energy charging systems: on-line information systems (geographical location of charging systems, availability of connectors for energy charging, price of energy, eventually battery swapping; automatic energy measuring and debiting systems, interoperability vehicle – charging systems (standardisation, data/energy automatically exchanged) and bi-directional capabilities, risk analysis and R&D on the boundaries of different charging schemes;
- Vehicle to/from driver information, support and command systems (vehicle status monitoring systems e.g. energy status, driver support and command systems for optimised energy use and recuperation, ADAS efficient driving e.g. for dynamic traffic and of route planning;
- Testing and validation of plug-in and electric vehicles;
- Secondary research on electro-magnetic compatibility, user acceptance, business models, standardization requiring demonstrations, validations and field tests.

- Renewable/alternative fuels and related drivetrains:
  Further research related to the energy and environment topic is aiming at the diversification of energy sources and at finding the optimum combination of drive train and energy carrier, e.g. renewable materials, hydrogen, biomass-to-liquid and electricity. R&D needs include:
  - Development of CO_2-neutral fuels from renewable materials (biogas/biomethane, hydro treated vegetable oil, biomass to liquid, bio-diesel, first and second generation ethanol, hydrogen, electricity, etc.) and strategies for their use (no adverse effects for food and feed production and markets);
  - Scenarios for alternative fuels and strategies for market introduction: alternative fuels versus conventional (balance, feedstock availability, conversion blending technologies), infrastructure, new biomass based compounds, oxygenated, etc.;
  - Optimisation of powertrains for alternative fuels: gasoline for alcohol fuels / blends, diesel for 2nd generation, CNG/biomethane;
  - Preparation of specifications of alternative fuels: impact on engine performance (degradation potentials), exhaust composition, future emissions;
  - Processes to convert a broad spectrum of primary energy carriers from several basic sources into a limited number of energy carriers suited for the transport system;
  - Assessment of climate and energy impact:
    Well-to-wheel analysis for various fuel options and drive trains,
    Life-cycle assessment for finding the optimum combination of drivetrain and energy carrier, e.g. renewable materials, hydrogen, biomass-to-liquid and electricity,
    Simulation packages for CO_2 indicators of various types of commercial vehicles.
- Technological innovations of the internal combustion engine and exhaust systems are important short-term paths towards fuel savings. R&D needs are seen in:
  - Further improvement of conventional powertrains:
    High-efficient combustion engine technologies allowing significant reduction of CO_2,
    Improved exhaust after-treatment system (filter and converter technologies),
    Optimisation of the overall system: “efficient engines - efficient fuels”;
  - Optimisation of the vehicle regarding energy management, energy recuperation, light weight structures (high-strength steel, aluminium, plastics, compound materials);
  - Alternative power for auxiliaries.

6. Safety

Challenge

Novel road vehicles, e.g. low weight, electrical vehicles, bring about safety challenges in terms of crashworthiness, electrical and fire safety, driving dynamics, acoustic perception and functional safety.

Until now efforts of the industry have focused on passive and active safety systems on board the conventional vehicle. Measures have now to be taken to ensure that low

weight, alternatively fuelled and electric driven vehicles will have the same high level of safety.

Objective

The objectives of R&D in the area of safety of the green vehicle are to ease its broad introduction by ensuring the same or even higher safety level as today and by a safe and convenient layout of the vehicle structure and the control of its traction system. Starting from existing safety requirements and standards, recommendations for the design of vehicles and components should be made, tested and validated that ensure safety in both accident situations and normal usage, handling and maintaining.

Major R&D Needs

- Safety aspect of new vehicle particularly hybrid and electric vehicles
  - Safety for alternative propulsion systems: integrated safety for the electrified vehicle (explosion fire, high-voltage, gas, EMC, noise), human machine interfaces, new body design and enhanced low-weight materials, distributed drivetrain architectures;
  - Tests and simulations of components (e.g. batteries, tanks) to work on specific risks present in electric or hybrid vehicles;
  - Functional safety and reliability;
  - Safety impact assessment methods for electric and hybrid vehicles and reviewing, assessment and definition of safety standards;
  - Electric vehicles driver assistance and cooperative systems for interaction and exchange of safety relevant information e.g. for vulnerable road-users (acoustic perception, sensors and actuators adapting to the object crashed into);
  - Crash mitigation for electric and low-weight vehicles (complete vehicle crash behaviour);
  - Collision avoidance and intelligent vehicle dynamics and adapted structural architectures;
  - High voltage systems/components: regular use (instructions), maintenance and repair, information/database systems for rescue/emergency services and intervention, post-crash automatic intervention (safe batteries, high-voltage systems risks);
  - Human body modelling for computer simulation of advanced protection systems, virtual safety testing, driver behaviour modelling.
- Vehicle-to-vehicle and vehicle-to-infrastructure communication and driver information support:
  - Connecting independent safety-systems, vehicles and roads, in an integrated and failure safe cooperative system optimised for energy efficiency and light weight vehicle usage;
  - Driver safety information with vehicle-to-vehicle and vehicle-to-infrastructure communication systems and post-crash information, e.g. on possible fire hazards for rescue operations;
  - ICT/ITS for safe and ecological driving: dynamic routing to avoid traffic jam and improve traffic fluidity thus reducing the CO_2 emissions, cooperative systems and Car-to-X communications; reliability of sensor and communication information.

7. Affordability and Competitiveness

Challenge

The availability of raw materials will remain a central challenge of the mid-term future. Besides forecast shortages in the oil and gas sectors, demand for materials like platinum, nickel, steel and copper will have significant upward impact on prices.
From the aspect of competitiveness, the challenge for the industry will be how to use rare raw materials in the most efficient way so as to continue production and avoid supply crises due to continuing increasing demand.

The trends towards development of more efficient and cleaner vehicles should be sustained by a parallel effort to decrease energy consumption in production and to develop appropriate recycling processes and reuse concepts.
Particularly for the electrical powertrain, novel challenges arise from the need for battery chemicals, precious metals and rare materials like e.g. magnets. Furthermore, the need for overall-efficiency gains is calling for the use of lightweight materials.

Objective

- Efficient use and protection of rare resources through selection, reuse and recyclability of materials and components;
- Adequate manufacturing systems including new forming, joining, assembly, surface protecting and painting processes;
- Flexible production and manufacturing of tailor-made vehicles.

Major R&D Needs

- Suitable materials:
  - Optimal utilisation of raw materials and their re-use at the end of life;
  - Exploration and use of sustainable alternative materials to replace depleted and costly existing ones (e.g. biomass as a raw material for the production of natural polymer systems);
  - Development and integration of adaptive material systems into vehicle structures for intelligent optimisation of vehicle comfort and performance;,
  - Development of advanced high performance, multifunctional materials and surfaces and improvement of enabling technologies to innovate the design of all main vehicle modules and key parameters (e.g. next generation of low density steel alloys and light metal alloys with improved properties and large scale application characteristics);
  - Simulation of mechanical behaviour of light-weight materials and adapted joining technologies under impact loading;
  - Performance improvements of components and systems (reduced weight and power consumption, higher efficiency), enabled by intelligent materials with emphasis on the integration of nanostructures and nanotechnologies into macro-systems;
  - Weight reduction of entire interior system including seats, trim, surfaces, damping system and functional system (e.g. cooling, ventilation, insulation, electrical components);

  - Development of new interior solutions and subsystems combining new materials manufacturing and design aspects to lead to significant weight reduction;
  - Improved quality and functions (e.g. scratch resistance, self cleaning, self healing, smell reduction, thermal properties, haptic quality);
  - Significant reduction of energy consumption for interior comfortabilty (heating, cooling, ventilation);
  - Development of surface treatments and paints used in processes which offer lower energy consumption.
- Green manufacturing for green vehicles:
  - Decreased energy consumption during the complete supply chain starting from raw material till the end of the vehicle's life;
  - Modelling of the transformation process: material extraction, foundry or processing, forming, treating, finishing, assembly, disassembly, scrapping, recycling, including heat generation, neutralization and graving, logistics, in order to compare materials production and transformation critical processes and reduce the impact on the environment.
- Affordable manufacturing for green vehicles:
  - Exploring and utilising opportunities offered by the establishment of new vehicle concepts and architectures also with regard to optimising manufacturing processes
  - Manufacturing processes effective in cost, time and quality by means of standard modularisation of powertrain components and related assembly processes
  - Specific attention to electric vehicles and the constituent components and sub-systems including batteries.
- Smart and flexible manufacturing to achieve cost efficiency, performance and robustness of manufacturing systems, with the constraint of increasing product variants and highly variable production volumes:
  - New factory oriented framework for the automation and robotics for open, modular and re-configurable control platforms;
  - Distributed and de-centralised controls and automation systems (self-controlled and self-managed objects, open systems, web based services, plug and produce capacity, embedded systems, industrial Ethernet);
  - Advanced sensor applications and software volumetric protection on machinery (vision systems, interaction of operations with workers, collaborative robots, machinery intelligence for operator protection) to increase safety of manufacturing.
- Digital manufacturing for integration of product and process development:
  - Modelling and virtual representation of factories, buildings, resources, machine systems and equipment;
  - Virtual product representations through complex and novel features simulation, for lifecycle development;
  - Standard automatic generation of machinery programs and their virtual validation considering interaction with real machine control.
- Virtual engineering: tools and environments for multi-domain and multidimensional performance management and for collaboration with suppliers.

8. **Implementing the R&D recommendations:** the next steps forward

This document recommends R&D directions and priorities of concern and relevance for the European automotive manufacturers and suppliers. These are formulated with the intention that the R&D topics are taken under the European Green Car Initiative and implemented as R&D during the remaining phase of FP7. However, one must be aware that the Automotive Industry operates on a world global market, affecting also its R&D activities. Therefore the R&D measures in the EGCI must be considered in this global perspective, and efforts should be taken for long-term consistency of the R&D directions and priorities as well as for the financing of the R&D actions.

Additionally to the R&D measure, the EGCI, as communicated by the Commission, also embraces other measures.
For instance the measures of public procurement should be explored as a mean of accelerating the market introduction of R&D results, e.g. procurement of alternative fuelled and electric driven buses and freight distribution vehicles in urban areas.
This should be a topic for discussion between the concerned parties.

The automotive industry is already in preparation to set up proposals on R&D for topics described in this document. However, the resource allocation to the different R&D topics in this document and in EGCI, and the timing of them within FP7, should be discussed and aligned with the priorities of the European Commission.

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