ERTRAC

European Road Transport Research
Advisory Council

Strategic Research Agenda

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LETTER OF INTRODUCTION

Envisioning Europe in 2020 from the threshold of this new millennium has made us keenly aware of both the hopes for our new and expanding European Community and the challenges confronting our society and environment. Road transport is woven throughout these hopes and challenges. It links us to each other, to our schools, employment and leisure activities. Freight transport is the lifeblood of our economy. The road transport industry provides employment across several sectors, and it is a source of both new technologies and manufacturing innovation. However, road transport also faces unprecedented challenges as demands for both personal mobility and goods transport continue to grow. At the same time, preservation of our natural environment is a growing challenge, energy supply is of heightened concern, and global competitive pressures demand ever increasing efficiencies.

For the past two years, research managers, technical experts and public authorities associated with the European road transport sector have been discussing these challenges and the possibilities for moving forward. We have reached three conclusions:

- Significant social, economic and environmental benefits can both be gained through improved knowledge and continued investment in research in the road transport industry.

- Both technical and non-technical research domains are key to finding solutions and making soundly based investment decisions for improving road transport within an intermodal system.

- The solutions required for our society can only be achieved through a multi-disciplinary, systems approach to research activities and the subsequent development and implementation by the private and public sectors at the European and national levels.

The members of ERTRAC invite you to utilize this first Strategic Research Agenda, which presents the elements of ERTRAC's Vision for 2020, and the expectations and targets for research in order to achieve this vision. It outlines detailed descriptions of the research areas and roadmaps of the path forward towards reaching the necessary objectives.

As ERTRAC moves forward in this unprecedented multi-stakeholder effort to implement an integrated Strategic Research Agenda, your reflections and contributions to creating a sustainable and competitive Europe are welcome.

Rudolf KUNZE
ERTRAC Chairman
Ford Motor Company / EUCAR

Jean Luc MATÉ
ERTRAC Vice Chairman
Siemens VDO / CLEPA

Helmut LIST
ERTRAC Vice Chairman
AVL List GmbH / EARPA

Mike McDONALD
ERTRAC Vice Chairman
University of Southampton

STRATEGIC RESEARCH AGENDA DEVELOPMENT PROCESS

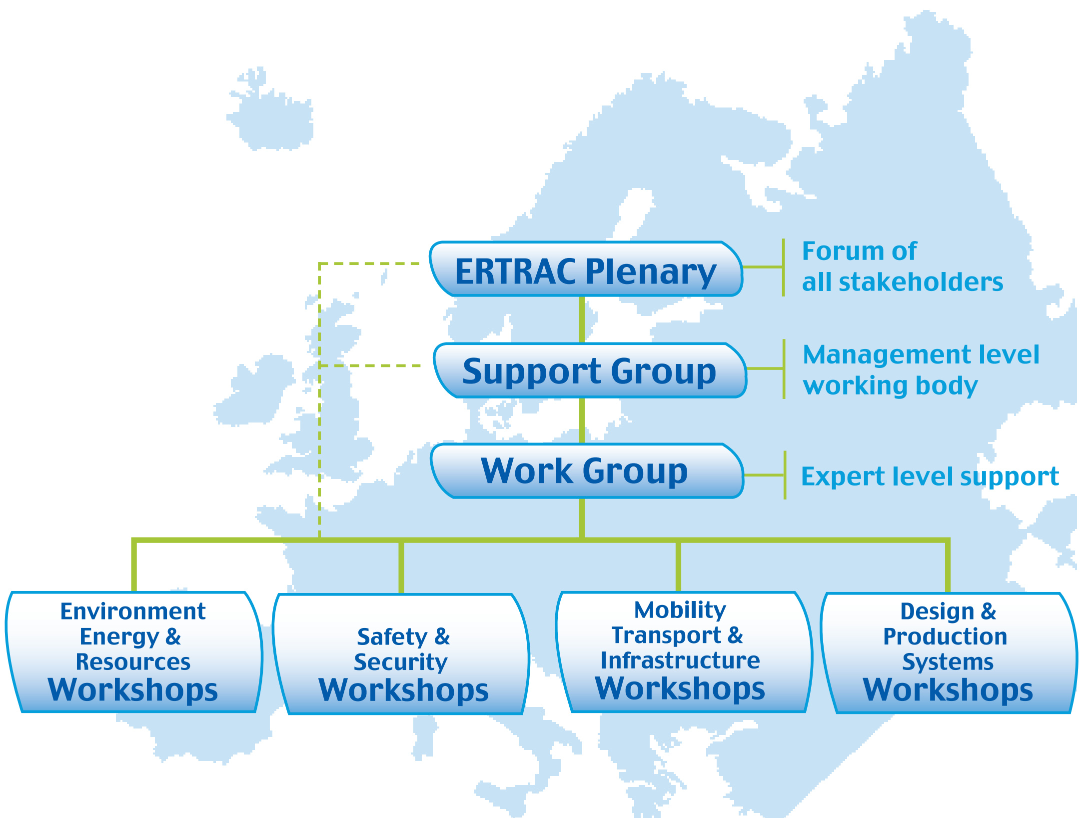
Due to the complexity of the issues and the number of stakeholders involved with road transport, ERTRAC has structured the discussion and development of the ERTRAC Vision for 2020 and Strategic Research Agenda around four pillars:

- Mobility, Transport and Infrastructure
- Safety and Security
- Environment, Energy and Resources
- Design and Production Systems

Naturally, there are inter-dependencies between these areas, and every effort was made to identify these and to take them into account.

The ERTRAC Plenary approved the structure and process for developing the Strategic Research Agenda. The responsibility for developing the content was assigned to the ERTRAC Work Group with the oversight of the Support Group. The content of the Strategic Research Agenda was developed by the Work Group in consultation with ERTRAC members including infrastructure providers, vehicle and fuel manufacturers and suppliers, non-governmental organizations, Member States, local governments and the European Commission. In addition, there was extensive consultation with other experts throughout Europe. A series of Workshops and ERTRAC internal reviews ensured that consensus was reached on the research themes.

The ERTRAC SRA will be reviewed and updated regularly to ensure an alignment by the various stakeholders around the different research issues and determine the priorities for action. As mutual interests on research areas are formalised, strategic research cooperations focused on a systems approach will be developed.



This SRA is organised in sections covering each of the four pillars. Each pillar is presented with a logical flow from the Vision statements to the targets for 2020, followed by a detailed description of the research areas which need to be addressed to achieve the Vision.

This is the first SRA which follows a true systems approach and integrates all the relevant research areas for a sustainable future road transport system. Every effort was made to capitalise the work already done in other European studies and roadmap projects concentrated on specific road transport themes.

All of the research areas are considered to be priority, but there are differences in the timing, technical difficulty, level of investment, and other factors. An assessment of the “Benefits to Society” and “Difficulty to Achieve” is provided on a scale from 1 to 5 for each of the research areas to provide the reader some sense of balance. These two indicators cannot be used alone to establish the priority of research as each research area is like a component that must be considered as part of a more complex system.

These assessment charts are presented for each major research objective across the four pillars. Some research topics appear under more than one objective; the "Benefit to Society" in each case refers to the specific research objective for that chart. The same topic may show different levels of benefit depending on the objective to which it is contributing.

The placement of the main research areas on the graphs indicating “Difficulty to Achieve” and “Benefit to Society” was one of the most difficult exercises. Each of the main research areas comprises of several activities that individually may have different merits than the research area as a whole. The following questions were considered in determining the relative values of the research areas:

Difficulty to Achieve

- **Technical Maturity:** Based on today's state-of-the-art, what is the status of development and how difficult is it to progress the R&D in this area?
- **R&D Implementation Costs:** What is the level of financial investment needed for R&D and for a successful implementation of the breakthrough technologies?
- **Competencies:** Are the competencies which are needed to achieve the objective available in Europe?
- **Time Horizon:** How soon can the technology be expected to contribute?

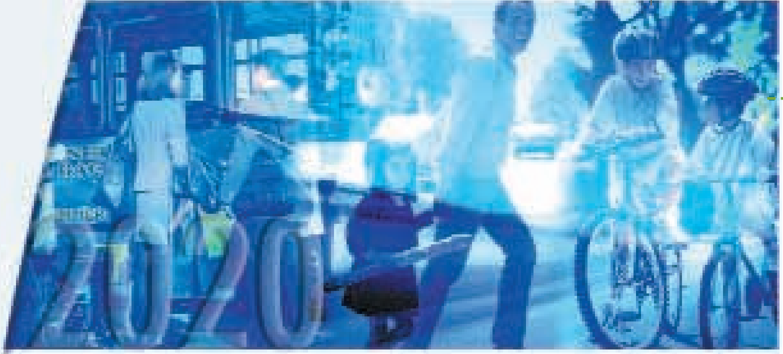
Benefit to Society

- **Energy and Environment:** How relevant is this R&D area for the critical issues related to energy and environment?
- **Safety:** To what extent does this R&D area improve transport safety?
- **Quality of Life:** Does this R&D area contribute to the quality of life in Europe, apart from safety and environmental aspects?
- **Technical and Economic Competitiveness:** To what extent will R&D in this area improve the competitiveness of the European economy?

As this SRA will serve as a reference for the definition of future research priorities, an effort was made to outline the different stages of research and development based on the OECD Franscati Manual[1]:

- **Basic Research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts.

[1] Franscati Manual, OECD 2002



- **Applied Research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
- **Technical Development** is systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

These definitions have sometimes been slightly modified to better fit road transport R&D. The three phases are illustrated in different colours in the roadmaps. As basic research, applied research and technical development are sometimes performed in parallel and the transition from one stage to anther happens over a period of time, the colours show the predominant R&D stage and the colours transition from one to another.

Additionally, the Champion and Supporters for each research area are identified. Champions take the initiative to lead the research and ensure the implementation of results. Supporters conduct research and develop the technologies that fulfil the needs and support the implementation of results. There are three groups identified comprised of the following stakeholders:

Industry:

- Road and Communication Infrastructure Providers
- Energy / Fuel Suppliers
- Vehicle Manufacturers and Suppliers
- Service Providers

Research Providers:

- Research Laboratories
- Universities

Public Bodies:

- EU Commission
- Member States
- City and Regional Governments

MOBILITY, TRANSPORT AND INFRASTRUCTURE

- MOBILITY, TRANSPORT AND INFRASTRUCTURE
  - Vision of enhanced mobility and an optimised and efficient seamless system
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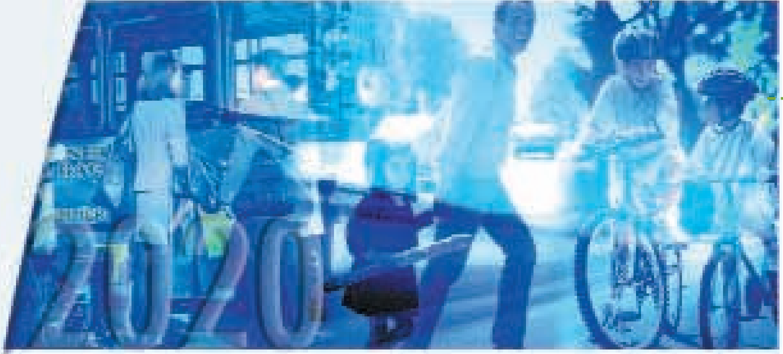
Vision of enhanced mobility and an optimised and efficient seamless system

MAJOR ASPECTS OF THE ERTRAC VISION 2020:

- People of all ages, incomes and physical abilities have ready access to convenient transportation thanks to a combination of collective transport and private vehicles within a better-integrated intermodal framework. If economically viable, new transport concepts shall be exploited where appropriate.
- The infrastructure network has been optimised through continuous investment. It is regularly monitored, upgraded and maintained to consistently high standards. It is used more efficiently, therefore optimising user services. Development of the infrastructure is supported by effective research in new materials and technologies.
- Traffic is smoother. Road networks are efficiently utilized and fully interoperable across Europe allowing seamless connections of road transport with other transport modes.
- Goods transport and logistics use the road and other modal infrastructure efficiently for urban deliveries or long-distance hauling.
- Land-use developments are better integrated with transport planning in order to eliminate unnecessary demand for transport and parking.
- A range of appropriate technical and policy measures are in place to manage mobility demand. They complement optimisation of the capacity utilisation of the road network and enhance quality of life.
- Real-time traffic and road data are available in an integrated information infrastructure to assist traffic management and to improve network management to enable people to make informed decisions.
- Interchanges between transportation modes provide the consumer with new features and services, including information and communication systems. These interchanges also fulfil economical and social dimensions.
- The available road space is used efficiently to support mobility needs of both people and goods through appropriate technology and policy measures.
- New approaches to the road transport system design are minimising the aesthetic impacts on communities.



Expectations and Targets

Mobility, Transport and Infrastructure considers two fundamental aspects of the road sector and objectives of the European Union: the need to provide for unhindered movement of people and the transport of goods. Within the context of ERTRAC, this section of the SRA considers basic factors for the provision of those needs. There are clear synergies with the other pillars of ERTRAC. Whereas, Safety & Security and Environment, Energy & Resources focus on those two important social needs, and Design & Production focuses on the competitiveness of industry, this section deals with the overarching issues of the basic demand for road transport, the developing needs of society and the essential aspects of managing one of Europe's greatest assets – its road network.

It is clear that according to all reasonable estimates, the provision for mobility of people and transport of goods in Europe will need to grow considerably by the year 2020[2]. This need will be driven by social and economic developments throughout the continent. Whilst considering the anticipated growth in demand, it is recognised that the greatest long-term benefits can be realised through integrated land use and transport planning. Additionally, important social changes, such as the estimated 17% increase in the number of households within the EU-25, compared with population growth of only 2%[3] , will modify societal travel requirements. This, and other aspects of change, underlines the requirement for research into the appropriate forms and capacity of mobility and transport provision. It must also be recognised that Europe's competitiveness depends on accommodating the 69% predicted growth[4] in the amount of goods transported. Research must be driven by the need to satisfy the predicted levels of personal mobility and freight transport. Clearly, additional benefits would result from fundamental redistribution and reshaping of the growth in demand for road transport. Such activities would require a multi-stakeholder approach involving parties from within and outside the transport sector.

The specific Research Targets are:

- Provide the necessary solutions to improve mobility and satisfy the expected 32% increase in individual demand for travel by 2020[5].

- Enable fluid and efficient movement of an increasing quantity of goods within the overall freight transport system.

- In order that quantifiable targets can be set in the future, a series of robust indicators, such as transport efficiency for passengers and freight, journey time reliability, user service levels and network efficiency, need to be developed. These measures, coupled with greater information provision, can allow appropriate choices to be made.

- Full compatibility of Member States' data and models relating to social trends and behaviours is necessary. Development and full integration of mobility forecast models into local and regional network management plans must also be achieved.

- Increase network efficiency through reductions in the impact of maintenance activities, prioritised road space and traffic management.

[2] Unless otherwise stated, all growth figures relate to 2020 and use 2000 as the reference.
[3] EU-25 Energy and Transport Outlook to 2030.
[4] EU-25 Energy and Transport Outlook to 2030.
[5] EU-25 Energy and Transport Outlook to 2030.

Research Area Descriptions

This section is structured into two key areas:

1• Mobility of People **2• Transport of Goods**

The first section, Mobility of People, considers six topics that cover basic issues of land use and planning, social trends (including changing demographics), improvements in the provision and efficiency of the sector and interactions with other transport modes. Many of these elements are transversal and have synergies with the other chapters of the SRA.

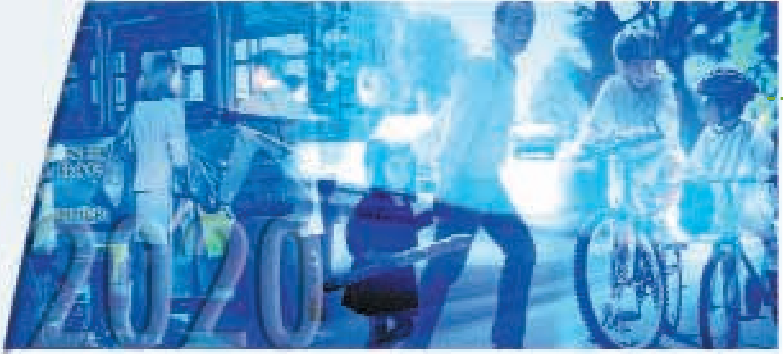
It should be recognised that although the second section, Transport of Goods, is detailed separately because of the specific needs of that sector, the overlap between the movement of people and transport of goods is strong, especially in the areas of infrastructure management. Therefore, the two sections should be considered together and many research activities are common to both.

1• Mobility of People

The Mobility requirements of all people need to be optimised across all modes and forms of transport. In order to achieve such optimisation on a large-scale, consideration must be given to understanding the underlying societal needs for accessibility and mobility. A better understanding of issues related to **Land Use** and to **Social Trends and Behaviours** is needed in order to bring about fundamental changes in transport usage.

Overall, major emphasis is given to improving the use that can be made of the road infrastructure. Innovative solutions in **Mobility Management** for making more capacity available within the existing system would generate improvements in efficiency. Special attention is given to those parts of society that are currently not well served by Europe's road transport system. In this respect, research should deliver improvements in passenger transport, both urban and long-distance, with easier and less time consuming **Multimodal Interfaces**. This will be supported by better quality and standards of **Information Provision** that provide appropriate support for the travelling public. More effective travel provision for both the motorised and non-motorised users of roads through the development of innovative **Mobility Concepts** is also recognised in the research activities. Finally, the financial requirements of all aspects of the road sector are considered. The major issue will be how new models could transform the methods by which taxpayers, users and consumers pay for both road use and for new infrastructure developments in order to improve overall sustainability in the sector.

Note: Some research topics appear under more than one objective; the "Benefit to Society" in each case refers to the specific research objective for that chart. See SRA Development process for further information.



1.1 Mobility Concepts

This research theme will deliver innovation in technological and systems development to provide a more cohesive transport system. Development of new concepts for the elderly and disabled travelling population will contribute to adequate provision. Concepts for vehicles and infrastructure will provide integrated vehicle guidance with appropriate road space solutions for motorised and non-motorised mobility. Availability of road space will be maximised with quicker return to operation after maintenance and incidents.

A wide range of choices must be made available such as pedestrian pathways, cycle routes, user-friendly public transport, new mobility services and private and shared vehicles as part of the mobility chain; all to be conceptualised with security, physical access and affordability in mind.

New Concepts

- New mobility systems should offer customers full "door–to-door" services, e.g. direct and safe links from residential areas to schools and shopping centres. Full, multimodal journey support from origin to destination (with maps, information, etc.), with customised HMI (Human–Machine Interface) and a range of additional services for the user.
- Concepts will be developed for the mobility and accessibility needs of elderly and disabled citizens.

New Vehicles

- Continued research in the design of buses, vans, guided vehicles, private and shared vehicles, two-wheelers, and new "driver-less" conveyance systems is needed to better meet customer requirements, improve safety and security and human interface.
- Advanced Driver Assistance Systems (ADAS), have to be further developed, evaluated for their potential impact on mobility, validated and implemented in order to inform and guide the road user to the optimal route, considering real-time traffic and modal transfer.
- Further research on Automatic Vehicle Guidance (AVG), in particular speed and distance management systems, is needed to evaluate its potential to increase road capacity.

Infrastructure

- A human-centred transport chain design requires affordable solutions for redesigning and modifying the existing physical infrastructure including pavements, road equipment, parking, access to stations, platforms as well as new concepts for new construction.
- New infrastructure concepts need to be developed to improve the mobility of pedestrians, bicycles, and disabled persons (e.g. bicycle lifts on slopes, pedestrian conveyors). Systems and models for providing optimum prioritisation of urban road space are needed.
- As a first step to the Automated Highway, systems enabling platooned vehicles should be evaluated for safety and capacity increase. Systems for high-speed bus and taxi corridors in dedicated lanes should be investigated.
- Marketing-based approaches for infrastructure use and entry into traffic streams (demand for slot entry) under saturated conditions should be evaluated.
- The concept of dedicated lanes and networks has to be further developed and tested. This should include light weight and reconfigurable passenger car infrastructures and reconfigurable and dedicated lanes for freight and 'e-Safety' and AVG enabled vehicles.
- Research on interactive functions (vehicle-vehicle, vehicle-infrastructure) is needed, in support of methods to improve the capacity of the road infrastructure. The linkages with traffic management, traffic information and short-term traffic forecasts should be considered.
- Infrastructure monitoring and maintenance management systems should be upgraded using advanced software, sensors and data transmission, responding to real-time local needs and reducing the impact of road works on travel time. Low cost, autonomous sensors for road condition monitoring have to be further developed.
- Quicker, more effective and durable road maintenance techniques have to be introduced. Improve the quality of recycling surface layers on site and systems for night-time operations.

- New technologies have to be developed for maintaining underground utilities (cables, pipes for water, gas, electricity and communication technologies) with a minimum of traffic disturbance in particular in urban areas.
- The overall effectiveness of separate lanes for road operations should be evaluated, as well as the need for upgrading the secondary road network (safe alternative and escape routes).
- New models have to be developed for the financing of both new infrastructure and the maintenance of existing infrastructure. New forms of cooperation between public and private parties must also be considered.
- Fuels, vehicles, and supply infrastructure need to be developed in harmony to ensure that fuels corresponding to the needs of customers' vehicles are readily available.

Studies

- Collect data and define models of human interaction and user acceptance to various modes of mobility.
- Identify and analyse technologies that better exploit HMI at the various levels in terms of information access, mobility services, etc.
- New business models for pan-European mobility services and capabilities must be created, simulated, tested, and implemented to increase consumer choice, enable informed decisions and to improve operator and network efficiencies. These business models need to involve all stakeholders to evaluate priorities for market introduction and to consider funding schemes including public-private partnership. Both bottom-up (customer requirements) and top-down (policy requirements) approaches have to be used. Service quality, human-centred design, affordability, increased accessibility and equity are prerequisites.

1.2 Land Use

Planning and assessment research on land use will provide authorities with integrated decision-making tools. This will provide more cohesive strategies for regional planning, urban design and local transport planning together with greater appreciation of environmental and social effects. Behavioural issues and e-service influences will be embedded in location based assessment models.

In order to meet the new demands for mobility and transport and address the shortcomings of today's systems, an integrated and comprehensive approach not previously seen is required. This approach should contribute to the ultimate goal of a sustainable transport system, considering the social, economic and environmental aspects.

Impacts

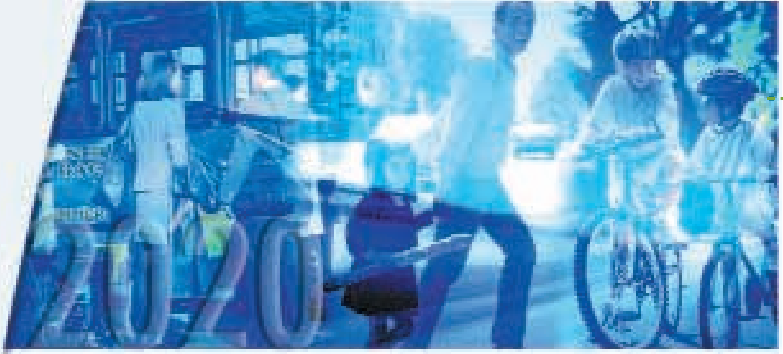
- Integrated land use and transport planning must focus on preserving and aiding the re-establishment of natural habitats. It must also focus on creating more liveable communities in which the need for and impact of motorised transport for daily tasks is eliminated or greatly reduced allowing pedestrians and bicycles to move more freely.
- Systematic impact assessment studies for new land use developments should be promoted.
- Studies into the impact of e-services are required.

Behaviour

- An understanding of the relationship between land use, mobility, accessibility and transport demand at both the local and regional level must be established. Segregation between living and working areas as well as relocation of production has to be reconsidered in the context of sustainability.
- A detailed understanding of local decision-making processes needs to be developed.
- An understanding of socially acceptable uses of land must to be developed.

Tools and Modelling

- The methodologies for integrating land use and transport planning need to be assessed.



▸ Appropriate Geographic Information Systems (GIS) technologies need to be developed bringing together all relevant data sources.

Integration

▸ Urban planning and architectural design need to integrate all elements: socio-economic data, the natural environment, housing, community life, and mobility and transport infrastructure. Efficient urban parking policies have to be developed.

▸ New models have to be developed for the financing of both new infrastructure and the maintenance of existing infrastructure.

▸ Improved methods for developing cost-estimates, including statistical uncertainty, for large infrastructure investments have to be developed.

▸ The impact of new infrastructure on land and housing prices has to be studied and the relation between land price and suburban expansion.

1.3 Social Trends and Behaviours

This considers the broader understanding of the decisions taken by the population and how those decisions will change with time and region. The research will consider how demographic and economic changes will modify mobility and accessibility needs. This will include aspects such as the effects of an ageing population, an increasing mobile labour market, household budgets, housing issues, and personal security concerns in order to provide essential information for decision makers.

Social and Economic Trends

▸ Studies are needed to review the impacts of expected demographic, economic and social developments in order to determine scenarios for development.

▸ Models to simulate the demographic development and the entire mobility chain under multiple scenarios are needed to thoroughly test and optimise the system before making costly investments. These include the economical and social evaluation of the transport system and the economics of multimodal transport. The optimisation should reach beyond all borders (urban, regional, state, Europe) in order to avoid inefficient local solutions.

Socio-economic Behaviour

▸ Studies are needed to better understand social values and how they influence the choices people make relative to housing, schools, work, family and friends, and leisure activities and how they are related to mobility. The real individual criteria for transport decisions should be examined, taking account of the expected demographic changes, the influence of flexible working hours and holiday periods, and the impact of greater mobility and freedom of movement between member states.

Data Collection and Interpretation

▸ New methods for data collection and treatment for demographic, mobility and transport demand patterns including origin, destination, time slot and energy consumption are needed. These must be harmonised and interrelated / aggregated at the EU level to provide the basis for understanding, modelling, and decision-making on demand management and land planning.

Tools and Modelling

▸ Simulation models must be created to link the cause and effect of mobility and transport demand in relationship to land use and to accurately predict outcomes of alternative choices for optimising liveability, economic viability, and sustainability.

▸ Methods for short, medium and long term traffic forecasts and for the measurement of social and economic impact of transport need to be developed.

▸ Forecasting methodologies, impact models and benchmarking indicators are required.

1.4 Mobility Management

Mobility Management includes a variety of measures including data collection techniques, business models, fiscal incentives and traffic management. Research will provide better systems for enabling investment to satisfy road usage requirements and manage the network.

Road infrastructure needs to meet the increase in mobility demand of the enlarged EU, for both passengers and freight, making optimal use of the available road space in a safe, efficient, and environmentally-friendly way.

Advanced Intelligent Transport Systems (ITS) need to be developed and gradually introduced, starting from information to the road users and moving towards assistance, guidance, and optimised infrastructure usage.

Data Collection

- In general, mobility is related to better opportunities for employment, living environments, cost of living and convenience, and often is a need to meet social and life needs (health care, education, shopping and entertainment). Each of these situations must be analysed, modelled and evaluated in terms of mobility alternatives and their acceptability with respect to the user as well as the community.
- An understanding of the root causes of mobility demand and the relationship to social values and the dynamics of communities is necessary.
- The ability to simulate mobility and transport flows based on reliable and accessible data is greatly needed. Efficient pricing tools and fee collection systems are needed to optimise travel and transport of goods over all modes, based on social, economic and environmental criteria.

Policies

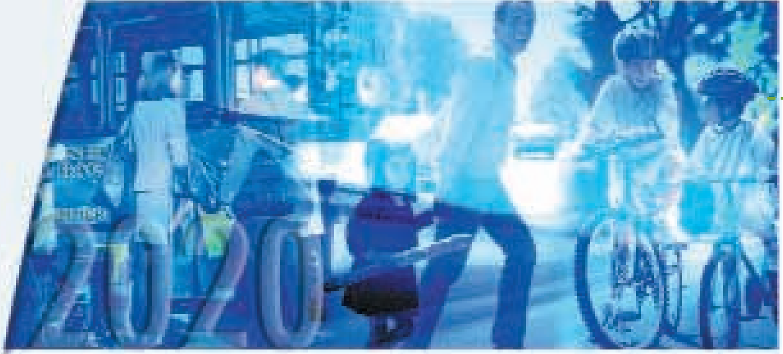
- The need for new designs integrating and optimising land use with mobility and transport needs is critical.
- New methods and organisational structures for cooperation are needed to manage mobility and transport demand. Network-wide strategies and technologies for demand management should be developed.
- Research is needed on the interrelationship between regional development and transport infrastructure, in particular in view of the EU enlargement in order to prevent the development of transport problems already experienced elsewhere.
- Possible mechanisms for de-coupling of transport and economic development need to be examined taking account of new communication technologies (e-commerce, e-learning, teleworking…). The impact of teleworking policies, including restrictions and thresholds, on mobility demand should be studied.
- The de-coupling of economic growth and mobility and transport demand and the role of market forces needs further study.

Payment

- The role of pricing in all its forms (road pricing, taxes, parking costs, subsidies, incentives) as a demand management tool needs to be studied. The effect of transport pricing policies and contribution of pricing practices towards accessible, equitable and sustainable transport systems goals should be measured.
- Further developments and implementation of electronic fee collection and dynamic road pricing have to be assessed for impact on traffic and demand. Reliability of the data and protection of privacy have to be assured.

Costs, Pricing and Finance

- Studies should include the assessment of the impact on environment, economy and social aspects. The impact of transparent transport charging on individual choice and collective interests should also be considered.
- New financing methods should be developed for the transport system as a whole and for infrastructure in particular to enable implementation of new technologies, maintenance.
- The relationship between quality and price elasticity of public transport and their effect on mobility choice should be evaluated.



Concepts

▸ New designs for the delivery of human-centred services must be studied in relation to the Human–Machine Interface (HMI) and more generally in relation to the Human-Mobility Interaction in order to incorporate the complex interaction between users and mobility services. This includes not only the operative tasks such as the selection and interpretation of information, but also more complex activities such as real-time dynamic planning, trade-off analysis and decision making.
▸ The ability to simulate the entire mobility chain is necessary to identify the weak links both from the customers' perspective and from the economic perspective of the service provider. (See also section 1.1 Mobility Concepts.)

1.5 Multimodal Interfaces

Seamless interfaces between different forms of road transport and the different modes will provide for the development of a holistic mobility system. Research must consider the links between different transport systems and how to offer passengers integrated route planning supported by appropriate information provision and data collection architecture. Also included are new concepts for intelligent and flexible infrastructure and for vehicles that interact seamlessly across modes.

Data Collection

▸ Methodologies for collecting and interpreting mobility/accessibility studies need to be developed. (See also 1.3 Social Trends and Behaviours.)

Communication

▸ Promote intelligent multimodal transport and routing systems on a European level.
▸ Assess the potential of various forms of Urban Intermodal Transport Management Centres.
▸ Development of automatic ticketing and fee collection for seamless mobility and goods transport within Europe. This should aim to stimulate an optimal distribution over all modes. (See also 1.6 Information Provision.)

Design

▸ New concepts need to be developed for multimodal connection areas that are all-mode friendly, allow seamless links, utilize real-time, multimode information systems, and offer other value-added services to the passengers (meeting place, multimedia, restaurants, shops).
▸ Further research is needed on technologies that can facilitate the transfer between modes (efficient interchange for passengers, people movers, more efficient park and ride).
▸ Improve the global quality (direct and indirect cost, time, physical access, security) of the entire mobility chain, including modal transfer.
▸ Develop new transport services that fill the gap between private and public transport (car pooling, collective taxis, bus on demand). Explore new car ownership systems.
▸ On the longer term, further research is needed on "cyber cars" with highly automated driving capabilities, available on call at any location and time, offering new solutions for door-to-door services.
▸ Explore new forms of collective transport: community-based transport pooling for repetitive activities (leisure, shopping, trips to work or school) through information and communication technology (ICT) tools for local organisations (sport clubs, businesses, schools, community centres).
▸ Develop and promote intelligent, safe urban systems.

1.6 Information Provision

Information Provision research will support the development of a reliable, efficient road transport system. Journey-times will be more reliable with comprehensive pre-trip information updated during the journey. Vehicle-vehicle, vehicle-infrastructure linkages will ensure optimum integration with other traffic and with traffic management systems.

Information infrastructure will provide access to a wide range of data, in particular assisting traffic management and fluidity and enabling people and businesses to make informed decisions thus decreasing journey times and reducing some of the detrimental effects of transport on the environment, as far as an increase in traffic demand due to better traffic conditions, can be avoided. (See Environment, Energy, Resources section). Consistent mobility and transport data allow for sound economic decisions based on criteria of acceptability and sustainability.

Information Service Delivery

- Network integration is needed between the physical and the information worlds to optimise mobility demand and planning through mobile and stationary communication points.
- Identification of what is the right information and when is the right time to optimise pre-trip planning and dynamic journey modification. Considerations include real-time, multi-modal arrival / departure information, travel time, route and costs comparison for all modes, events, weather and safety warnings, specific user constraints (accessibility, security).

Business Models

- New business models are necessary to meet the changing consumer demand and at the same time contribute to more sustainable transport solutions. Effective education and awareness programs need to be developed and tested to ensure that citizens can easily access and utilise the information to plan their trips.

Technologies

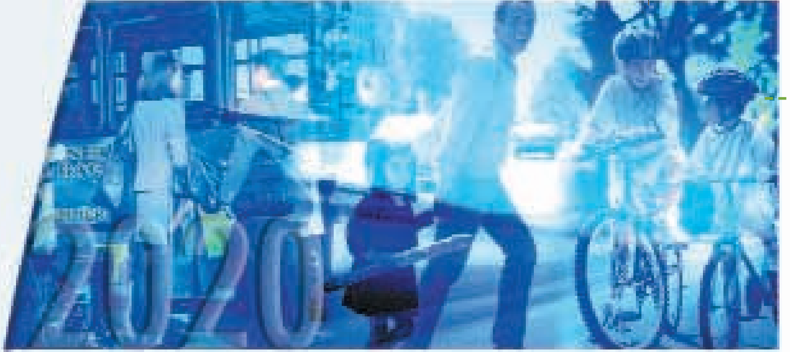
- Development of real-time traffic information systems, in combination with a European digital road map database, including traffic restrictions, road condition data, and parking availability, should allow reliable travel time prediction and better route selection.
- New mobile, two-way and multimedia communication technologies and systems should be developed and harmonised for use throughout Europe.
- Intelligent transport management and infrastructure systems integrated into broader networks (e.g. food distribution, energy, industrial production) could allow a more responsive multi-modal transport system capable of resisting and recovering from shocks.
- The potential of personal electronic devices should be evaluated in view of the impact on multimodal transport.

Base Data

- Standards are needed for traffic information and routing systems in a multimodal transport environment, e.g. for location, timing, metadata common referencing systems.

Behavioural Response

- Develop human centred services for mobility providing real-time multimodal traffic and travel information and personal communication. These should enable informed decision- making regarding personal preferences and environmental impact.
- Develop and evaluate services to improve the utilisation of travel time.
- Studies on HMI (Human-Machine-Interaction), both ergonomic and cognitive, as well as on consumer values and decision-making, are needed to guide the development of mobility alternatives. Better information on real costs, safety, personal security multimodal solutions and impact on sustainability should improve informed decision-making.
- The safety aspects of in-car information and communication have to be investigated considering customised interfaces minimising the risks and avoiding interference with the driver's tasks.
- Study the effects of information presentation on understanding and behaviour.



Mobility of People

MOBILITY CONCEPTS Champion: Public Bodies, Industry Supporters: Research Providers	NEW CONCEPTS	Cooperative systems, private-public transport, concepts for elderly or infirm
	NEW VEHICLES	Guided vehicles, automatic platooning, new vehicle concepts
	INFRASTRUCTURE	Optimisation of urban road space, road maintenance, support for non-motorised mobility
	STUDIES	Evaluation of models for quality and reduced cost, understanding barriers to new systems and services
LAND USE Champion: Public Bodies Supporters: Industry, Research Providers	IMPACTS	Environmental impact, long.term influence of traffic and land use, impact of e-services
	BEHAVIOUR	Land use and competitiveness, understanding local decision making, socially appropriate land use planning
	TOOLS AND MODELLING	GIS technology, planning, transport impact assessment
	INTEGRATION	Decision processes for optimising coordinated land use and transport planning
SOCIAL TRENDS & BEHAVIOURS Champion: Public Bodies Supporters: Industry, Research Providers	SOCIAL ECONOMIC TRENDS	Demographics, household budgets, housing, personal security concerns
	SOCIO ECONOMIC BEHAVIOUR	Benefits, costs, decision factors
	DATA COLLECTION AND INTERPRETATION	Harmonisation of best practices and methodologies
	TOOLS AND MODELLING	Mobility forecast, impact of transport system, evaluation
MOBILITY MANAGEMENT Champion: Public Bodies Supporters: Industry, Research Providers	DATA COLLECTION	Harmonisation of methods, real-time information for traffic management, forecast tools
	POLICIES	Impact studies of transport policy options, impacts of future driving environments on travel choices
	PAYMENT	Payment systems, fee collection for transport and other services
	COSTS, FINANCING, PRICING	Business models for cost and financing, impacts of pricing in urban areas
	CONCEPTS	System-wide optimisation of concepts, dynamic wave, real-time traffic information for users and management
MULTIMODAL INTERFACES Champion: Public Bodies, Industry Supporters: Research Providers	DATA COLLECTION	Mobility studies, traffic flow
	COMMUNICATION	Multi-modal route planning, co-operative systems
	DESIGN	User-focused design, intelligent infrastructure design, new vehicle concepts
INFORMATION PROVISION Champion: Public Bodies, Industry Supporters: Research Providers	INFORMATION SERVICE DELIVERY	Trip information, multimodal provision for different user groups, process understanding
	BUSINESS MODELS	Public and private provision, implementation
	TECHNOLOGIES	Harmonisation, multi-channel solutions, vehicle-to-vehicle-to-infrastructure communications
	BASE DATA	Mapping accuracy, location, short term forecasting, interoperability, integrated information, integrated traffic management
	BEHAVIOURAL RESPONSE	Long and short term response, relationship between travel, time, reliability

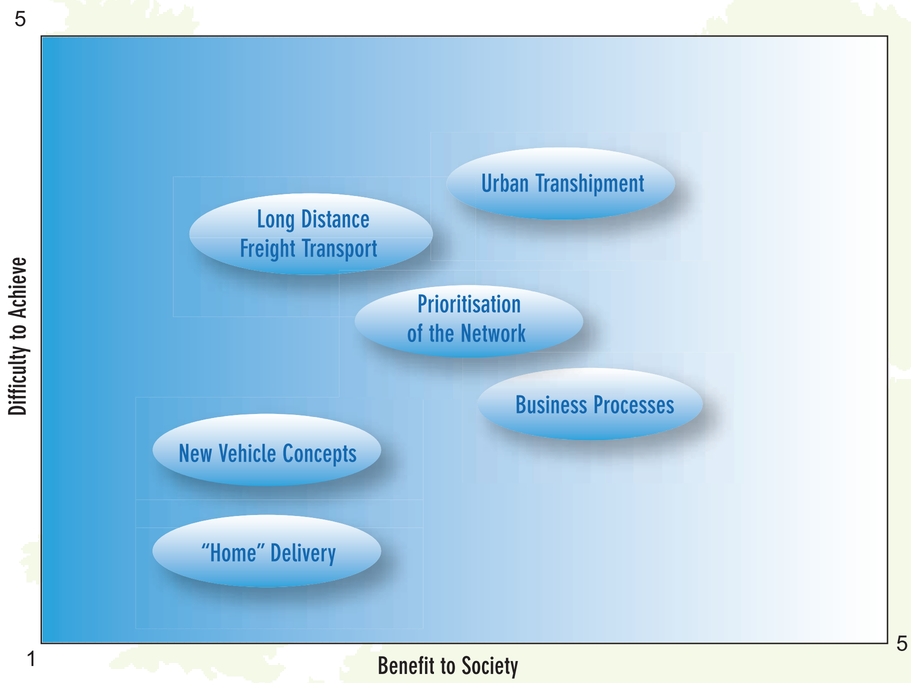
TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research, Applied research, Technical development

2• Transport of Goods

Freight transport has to be optimised over all modes in order to improve the efficiency and overall effectiveness, to avoid unnecessary transport and improve **Business Processes**, and to reduce the impact on the environment. Clear focus needs to be placed on **Long-Distance Freight Transport** and the **Prioritisation of the Network** in order to support the efficient and unhindered passage of goods. In Europe's congested areas, the relation between different transport modes and different forms of road transport needs to be improved with greater emphasis on using the right vehicle in the right place with optimised **Urban Transhipment**. The links to other modes have to be made easier and less time consuming. **New Vehicle Concepts** are needed for modal transfer, transport logistics and quieter, cleaner delivery of goods.

Improvements in goods transport, both urban and long-distance, and improved concepts for transport logistics and efficient freight delivery must reduce congestion on major axis and city centres while improving service levels. Finally, new technologies will have a major impact on shopping patterns that will require better services for, and understanding of, "Home" Delivery and all the other methods by which goods are available at a time and location convenient to the customer.



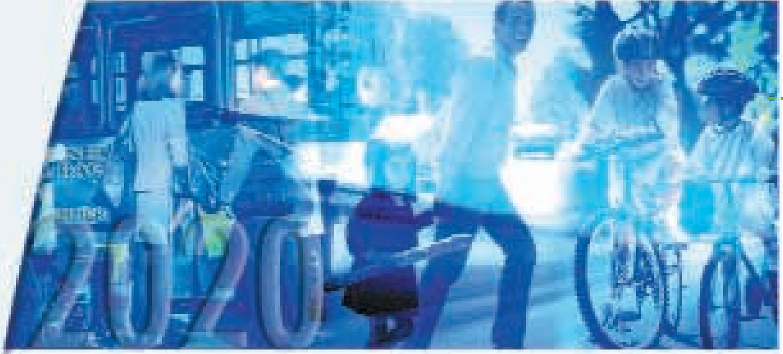
MOBILITY, TRANSPORT AND INFRASTRUCTURE
Vision of enhanced mobility and an optimised and efficient seamless system
Expectations and Targets
Research Area Descriptions
1• Mobility of People
2• Transport of Goods

2.1 Business Processes

Business Processes can be made more efficient through optimised logistics and improved tracking and information. Research into on-line tracking and maximising the use of load space will reduce costs and improve security.

Optimised Logistics

- Innovative and economically viable solutions optimising goods transport and avoiding the demand, considering the whole supply chain logistics.
- Robust indicators on freight transport efficiency, journey time reliability, and network efficiency need to be developed.
- Develop a harmonised pan-European goods transport database of performance, origin-destination, costs and prices, to be coupled to national systems in order to provide inputs to modelling and decision-making processes.



‣ Study the optimisation of freight flows based on availability and real-time, multi-modal information considering all modes including route and costs comparison. Identify the complementarity between road and rail transport. Optimise and design new logistic set-ups (transport flow, 24-hour economy).
‣ Studies are needed on alternative delivery scheduling in order to reduce congestion in streets.
‣ Examine how to develop sustainable solutions in a market driven environment for the transport of goods.
‣ Those features of Intelligent Transport Systems (ITS), including Advanced Driver Assistance Systems (ADAS) and Automatic Vehicle Guidance (AVG), that allow improvements in the efficiency of transport should be assessed for acceptability, reliability, safety, liability; affordability to everyone. Cost benefit analysis should be performed, and implementation in Europe should be coordinated.

Tracking and Information
‣ Develop tracking technologies in order to establish a seamless information chain to increase planning efficiency, achieve productivity gains and foster security. Harmonise common electronic letters and tags for seamless freight tracking and tracing across Europe.
‣ The problem of confidentiality of data in the freight sector should be investigated, and solutions proposed.
‣ Applications of navigation and positioning systems need to be developed for tracking the position of vehicles and for collecting real-time traffic information. Investigate potential for improved and more accurate localisation to enable new functions such as parking slot identification, lane keeping, distance relative to other vehicles (platooning) based on vehicle-vehicle and vehicle-infrastructure communications combined with the GALILEO satellite system.
‣ More studies are needed to identify the strategic value and the use of information for infrastructure managers and for agents competing on the market in order to understand the balance between transparency and competition.
‣ Open architecture standards and harmonized data transmission modes are needed. The use of existing open standard systems should be evaluated.
‣ Develop new concepts for optimising the use of vehicle loading space for multi-drop loads.

2.2 Urban Transhipment

Urban Transhipment is focused on reducing the impact of freight movements upon residents whilst maintaining, or increasing overall efficiency. Research will consider the location of depots and relations with extra-urban road transport and other modes. New concepts for urban-friendly freight distribution vehicles, loading/unloading systems and infrastructure will reduce noise and pollution.

Concepts of Urban Delivery
‣ Innovative urban delivery systems need to be developed that are tailored to the local needs of individual urban areas.
‣ New systems need to be developed for greater efficiency for street-based loading and unloading. This should consider vehicles, goods transport units, street design, traffic management, the frontages and interior designs of businesses.

Optimisation of City Logistics
‣ Studies into the complexities of urban freight transport are required which should develop solutions for overcoming difficulties of loading and unloading, parking and planning. Methodologies and systems for the designation of specific urban truck routes, which may be variable in time, need to be developed.
‣ City logistics have to be developed for transhipment to quieter, lower-emission vehicles of appropriate size, or to other transport systems (conveyors, tubes).
‣ Public-private models for urban freight delivery should be developed.

New Vehicle Concepts
‣ New solutions for underground, automated freight transport have to be investigated. The feasility of full driving automation on dedicated infrastructures for commercial vehicles should also be evaluated.
‣ New modular vehicle systems and load carrier concepts are needed for all portions of the logistics chain.

2.3 Long-distance Freight Transport

The transport of goods across Europe can be made more efficient with a better understanding of distribution practises. With appropriate infrastructure, new concepts such as road-trains could dramatically increase the efficiency of individual vehicles for long-distance journeys. Dedicated infrastructure could allow roads, bridges and tunnels to be optimised for particular types of vehicles reducing maintenance and environmental impact. This section should be considered in conjunction with Safety & Security and Energy, Environment & Resources with particular reference to sections 3 and 6 respectively.

Logistic Processes

- Study the optimisation of long-distance logistics.
- Identify the impacts of information on distribution practices and the effect on improved journey time reliability.

Vehicle Related Issues

- Develop the concepts for the Truck of the future including modular goods carriers and effective road-rail combinations.
- Develop intelligent Inter-modal Transport Units (ITU) for modular goods movement on a European level.
- Develop standardised concepts for effective goods movement throughout the entire logistics chain, not just the transport portions.

Infrastructure

- Develop network level systems to support the transit of heavy vehicles. This should consider the issues of restrictions for bridges, tunnels, steep gradients and congested or environmentally sensitive areas. Real-time and seasonal effects will need to be examined to maximise the effectiveness of the system in all weather conditions.
- Develop new tools and models for the efficient asset management of both overall network and individual sections to improve the overall life cycle costs.
- Market-based approaches for infrastructure use and entry into traffic streams (demand for slot entry) under saturated conditions should be evaluated.
- Solutions need to be developed using new dynamic traffic management and infrastructure technologies in order to improve the use of the existing infrastructure and reduce bottlenecks.
- Develop appropriate road classifications for the efficient operation of modular vehicles and road-train combinations.
- Systems for platooned trucks in dedicated lanes should be investigated.

Intermodality

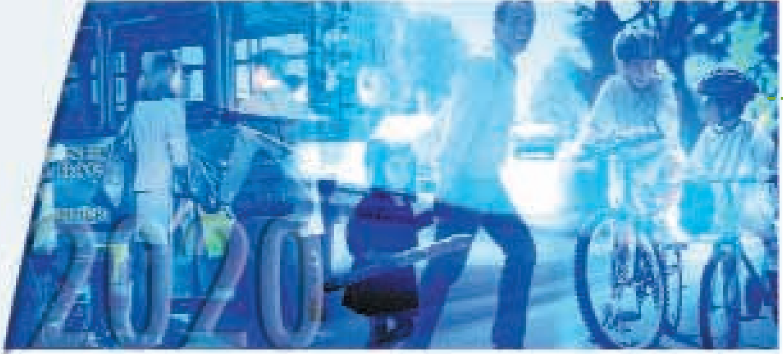
- New solutions, operational throughout the enlarged EU, should be designed for long-distance transport combined with efficient modal transfers. New concepts are needed for multimodal connecting, transfer, and rest areas offering new services to truck drivers.
- The economics and the competitiveness of multimodal transport of goods have to be studied considering new optimised truckloads.

2.4 Prioritisation of the Network

Prioritisation of the Network can bring about significant benefits for both the freight sector and the passenger sector. Optimisation of the road space will ensure that vehicles adopt routing patterns that minimise the any adverse impacts. Research will support systems for segregating traffic with dedicated infrastructure and prioritised traffic management. Methods to assist the booking of optimise slots for individual good vehicles can increase reliability and efficiency.

Cost Allocation

- Investigate new options, including business and legal models, for private sector involvement in traffic control centres and data ownership, management and dissemination.
- Evaluate links between efficient traffic management and community and environmental goals.



Data Collection

New technologies are needed for cost effective traffic data collection on all networks (urban, rural, main roads and motorways) with improved performance over existing technologies. Communication with the navigation systems in the vehicles, Traffic Dialog Systems (TDS), Floating Car Data (FCD) and anonymous data transmission should be further developed. Mobile communication may enable the collection of data from distributed, moving vehicles in real time and could allow more comprehensive assessment effects of traffic effects.

- Measuring methods for congestion, travel time reliability, network performance monitoring and service level indicators are needed.
- Real-time travel time prediction methods and increased reliability of short term traffic forecasting models are necessary to improve information and management.

Optimised Road Space

Road traffic congestion continues to increase, especially in and around the large urban areas. In most of the densely populated areas, large developments of the road infrastructure, particularly of the type required for heavy vehicles, are no longer possible for environmental reasons and lack of space. Other solutions need to be found using new dynamic traffic management and infrastructure technologies in order to improve the existing infrastructure and to optimise its use. In the longer term, the strategic evolution of infrastructure and transport supply needs to be analysed.

- New Information and Communication Technologies (ICT) and ITS have a large potential for improving the efficiency of passenger and freight transport. Further research on the implementation and the assessment of these technologies for application in road transport is required.
- Assessment tools are required for traffic management strategies, based on dynamic capacity optimisation models, taking into account dynamic lane allocation, tidal flows, two-way communication with the users, ICT and ITS, and electronic parking management services.
- Dynamic, information led traffic management and control models should be created utilising embedded information, real-time data transmitted from the vehicles (position, speed, origin, and destination), individual route planning, access control to routes, lanes, and parking. More automation in traffic flow control should be developed.
- As traffic management becomes more dependent on information flows, the reliability against intrusions should be ensured, and fallback strategies should be specified.
- Methods are needed for intelligent, dynamic lane allocation considering the effects of variable lanes and speed limits for different traffic flows, taking into consideration all types of vehicles (trucks, cars, busses, two-wheelers) private or public.
- Links between traffic control centres across Europe should be improved in order to enable traffic management on long stretches including alternative routes, incident management and congestion management. Network-wide strategies and technologies for road traffic should be developed.
- In order to reduce road closures more effective traffic incident and emergency management methods need to be developed, based on full chain cooperation (transport authorities, road-side assistance, emergency services, insurance).
- Methods for mobility and traffic management in case of special events, man-made and natural, are needed. Strategies based on risk evaluation should be developed.
- A long-term strategic analysis is required on the evolution of infrastructure and transport supply.
- In view of the EU enlargement, the European road network will have to be improved, expanded, upgraded and harmonised, eliminating traffic bottlenecks and structural congestion, in consideration of safety, environmental impact and economy. A better understanding of removing bottlenecks is needed to provide the required capacity. Harmonised decision indicators and standards for the level of service of the road infrastructure for all road users have to be established.
- Pilot studies and validation projects are needed for the practical installation of ICT and ITS, intelligent pavements enabling dynamic traffic management, allowing dynamic allocations of lanes, intelligent merging systems, speed control, guidance systems, and lane prioritising for collective transport, high occupancy and emergency vehicles. These pilot studies should include new technologies for electronic road markings, pavement surface colouring and dynamic lane barriers.

2.5 "Home" Delivery

"Home" Delivery is the final stage of the distribution chain and in explicitly linked with personal mobility. Research in this area will provide solutions to problems of goods transport, including that by passenger cars, in residential areas. Coupled with studies of the impacts of e-commerce, new concepts for tracking and delivery systems can be developed.

Tracking Goods
- Innovative optimised delivery systems need to be developed.

Study e-Commerce
- In-depth study of the impacts of e-commerce on future freight transport is needed.
- Consideration of the impact of "home" delivery on residential traffic is required.

Interrelation of Car Use and "Home" Delivery
- Investigate the relationship between "home" delivery and car and public transport usage.
- Develop innovative systems to integrate car usage and home/workplace delivery systems.
- Develop appropriate local area distribution points e.g. drive-in centres, park and ride facilities.

2.6 New Vehicle Concepts

New concepts can be developed for cleaner and quieter vehicles for urban delivery and night-time operation. For reasons of both safety and efficiency, systems will be needed to optimise the use of driver's hours. Social and efficiency gains can also be achieved through the development of new multifunctional vehicles (such as post-buses) to integrate different types of passenger and freight transport.

Environmentally Friendly Vehicles
- Develop new concepts for quiet and clean vehicles for urban and night-time distribution.
- Develop multi-powered vehicles, e.g. flexible catenary systems for light-trucks.
- Develop systems for lower noise during the loading and unloading operations, in synergy with 2.2 Urban Transhipment, Concepts of urban delivery.

(This section should be considered in conjunction with **ENVIRONMENT, ENERGY, RESOURCES**, especially sections 3.1, 3.2 and 3.3.)

Driver Assistance
- In combination with systems to support safer driver operation, develop technology to monitor performance in order to support increased flexibility in the use of driver's hours.

Multi-purpose
- Create and test concepts for multi-purpose vehicles, for example passenger/freight carrying vehicles.
- Develop business processes to support multi-functional operation.
- Create and test concepts for multi-modal vehicles.

Transport of Goods

BUSINESS PROCESSES Champion: Industry Supporters: Research Providers	OPTIMISED LOGISTICS	Consideration of social needs, alternative concepts, vehicle/container distribution, minimised energy intensity, transhipment costs
	TRACKING AND INFORMATION	RFID (radio frequency identification devices), new approach to vehicle loading space, on-line tracking of goods
URBAN TRANSHIPMENT Champion: Public Bodies, Industry Supporters: Research Providers	CONCEPTS OF URBAN DELIVERY	Location of depots, intermodal concepts
	OPTIMISATION OF CITY LOGISTICS	Loading / unloading systems, optimised platforms (noise, pollution), new optimised modular load systems and vehicle configurations
	NEW VEHICLE CONCEPTS	Integrated modular vehicle and load carrier concepts covering different parts of the logistics chain
PRIORITISATION OF THE NETWORK Champion: Public Bodies Supporters: Industry, Research Providers	COST ALLOCATION	Road freight charging, internalisation of external costs
	DATA COLLECTION	Data management tools
	OPTIMISED ROAD SPACE	Traffic flow segregation, prioritisation, guidance through prioritised networks, Lane and slot booking
LONG DISTANCE FREIGHT TRANSPORT Champion: Public Bodies, Industry Supporters: Research Providers	LOGISTIC PROCESSES	Impacts of information on distribution practices, improved journey time reliability
	VEHICLE RELATED ISSUES	Road-trains, impact of "platooning" on other road users, real and virtual toll bars
	INFRASTRUCTURE	Dedicated infrastructure
	INTERMODALITY	New interface systems, load carriers and vehicle concepts adapted to intermodal (road-rail-air-water) logistics needs
"HOME" DELIVERY Champion: Industry Supporters: Public Bodies, Research Providers	GOODS TRACKING	Optimised tracking and delivery systems
	E-COMMERCE STUDIES	Impacts of e-commerce
	INTERRELATION OF CAR USE – HOME DELIVERY	Impact of new processes on urban goods transport and personal mobility demands
NEW VEHICLE CONCEPTS Champion: Industry, Public Bodies Supporters: Research Providers	ENVIRONMENTALLY FRIENDLY VEHICLES	Cleaner, quieter vehicles for urban delivery and night delivery
	DRIVER ASSISTANCE	In-cab systems to support drivers, technology to increase flexibility of drivers' hours
	MULTI-PURPOSE CONCEPTS	Multi-purpose vehicles, integration of goods and people services (location, communication, tracking and tracing)

TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research Applied research Technical development

SAFETY AND SECURITY

Vision of a safe and secure road transport system

SAFETY & SECURITY
- Vision of a safe and secure road transport system
- Expectations and Targets
- Research Area Descriptions
  - 3• Accident Prevention
  - 4• Accident Impact Mitigation
  - 5• Road Transport System Security

MAJOR ASPECTS OF THE ERTRAC VISION 2020:

- The road infrastructure is easily understood by all road users and designed to minimize road user mistakes. It limits the consequences of driver errors.
- Roads and infrastructures, including road markings, are built, upgraded, maintained and inspected according to high safety standards and procedures.
- Integrated vehicle safety systems are further developed to prevent accidents and mitigate their effects. They greatly improve the driver's control of the vehicle. Nevertheless, the driver always remains in control.
- Intelligent roads and intelligent vehicle systems interact and communicate with the driver. The systems provide guidance, warn of danger and enable safe driving behaviour.
- Vehicle-to-vehicle compatibility is enhanced, to favour traffic safety in areas with high density of road users.
- Vehicles and infrastructure are minimising the impact on the most vulnerable road users, in particular pedestrians and cyclists.
- The inappropriate use of powered vehicles in sensitive parts of urban areas is restricted.
- The road system is continuously monitored to ensure that high safety standards are maintained.
- Continuous and attractive training and safety awareness programs reach all road users, in particular during early education at school.
- Effective enforcement methods for enhanced road safety (e.g. for speed limits, seat belt use, influence of alcohol or drugs while driving) are available.
- An agreed methodology for gathering and analysing accident causation data is in place. The data is available for necessary, in-depth accident investigation.
- Safety challenges from new fuels and energy sources are addressed through standards, design practices and operating procedures.
- Databases are used to help enforcement of traffic regulations and assess the nature and magnitude of security problems across boarders without impinging unacceptably upon the liberties and the privacy of citizens.
- Respecting the right of privacy for citizens, vehicles are equipped with theft deterrent systems, vehicle tracking technology and personal safety systems such as those based on biometrics.
- Freight security is improved by advanced tracking and monitoring technologies such as load identification.
- Response scenarios for emergency rescues and evacuations, post-accident treatment are enhanced, as are countermeasures against illegal operations such as hijackings and vandalism. Optimised cooperation and performance between the police, authorities, fire brigades and rescue teams supports this task.

Expectations and Targets

Road transport safety has improved significantly over the last three decades as indicated by an 80% reduction in fatality risk per distance travelled and a 50% reduction of the total number of fatalities in the EU. This exponential decrease is projected to continue as new safety measures and technologies penetrate the market, but nevertheless the current situation with roughly 40,000 road users killed and 1.7 million injured on European roads requires further efforts.

Ambitious targets have been set to improve this situation in a variety of countries. A target of 50% reduction in road fatalities in the EU by 2010[6] has been set, and the FURORE report calls for 75% by 2020[7]. These targets can only be achieved through enhanced efforts including contributions from research. While these targets can be an efficient method to enhance development and implementation of safety relevant measures, efforts to improve safety will be required as long as accidents happen.

Technology applications on the vehicle, the infrastructure and in communication links can help both to avoid accidents and to mitigate their consequences. However, an optimum utilisation of their potential is only possible if they are applied in an integrated way, taking into account the behaviour of road users themselves. The behaviour of appropriately trained road users, informed through advanced information technologies, is equally important. Once an accident occurs, mitigation systems including improved infrastructure, vehicle design safety technologies and information management can help reduce fatalities and serious injuries to the lowest possible level. The guiding principle and starting point should be to adapt the system to the limits and capabilities of the road user.

A significant factor for past improvements in safety levels have been changes in vehicle design. However, the large differences, up to 500%, that are visible in road safety levels between the EU countries indicate that other factors must be equally important. These large differences in safety levels between member and accession countries are not sustainable and an equally low level of accidents and their consequences needs to be achieved.

The science of accidentology aims to provide a consistent and in-depth knowledge on the root causes of accidents in road transport. This provides the foundation for avoiding accidents and their negative consequences as well as for the assessment of effectiveness of any measure taken. Another important research target is to develop an accepted methodology for investigating the potential and real-world impact of any measure or technology, thus providing knowledge on the effectiveness of these measures.

Road fuels are handled today with a high level of safety. New fuels such as hydrogen present safety challenges that can be overcome with appropriate research.

Intelligent systems, as well as contributing to safety, offer the potential to enhance security and free movement of both people and goods. Research on improved communication, security networks and tracking technologies will ensure this goal.

Significant improvements in road safety will strongly depend upon the implementation of an Integrated Safety approach. Accidents involve vehicles, road infrastructure and people, whether they be drivers, passengers, pedestrians or other road users. A focus on one of these alone can only be partially successful, and true progress will only come when interactions between the driver, vehicle and road infrastructure are effectively employed. Overcoming classical boundaries will serve as an enabler for a systems approach for accident prevention and mitigation.

The specific Research Targets are:

- New research solutions could contribute up to 30% of the target reduction in fatalities. Accident prevention could contribute 55-65% of the total gain. Accident mitigation could contribute 35-45%.
- Member states should all achieve an equally low level of accidents.

[6] White Paper, European Transport Policy for 2010: Time to Decide; EC, 2001

[7] FURORE-Future Road Vehicle Research, R&D Technology Roadmap, 2003

- Member States should achieve full compatibility of accident research databases and methodologies.
- Research should ensure that new fuels will be handled with the same level of safety as road fuels are handled today.
- In an enlarged Europe, the security of people and goods in transit will improve over the levels of 2000.

Research Area Descriptions

To structure the research theme "Safety and Security" it has been divided into three key research areas

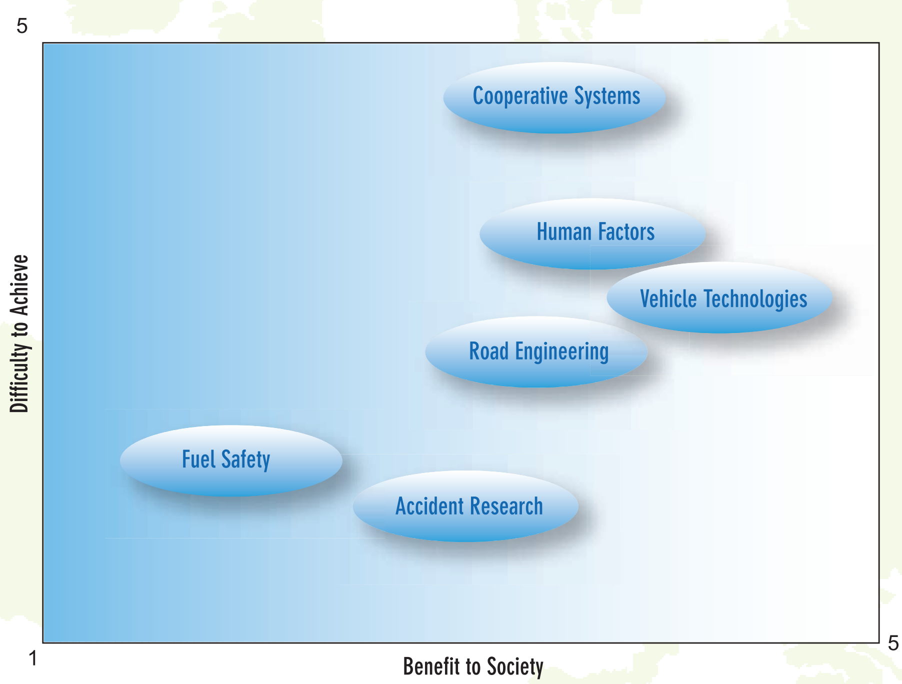
3• Accident Prevention **4• Accident Impact Mitigation**
5• Road Transport Systems Security

For these key research areas, opportunities are identified related to the road users, the road and street environment, the vehicles, and traffic management and information systems. Overall, the objective is to define and develop new safety functions from the perspective of the user and to focus on systems research rather than on individual technologies.

3• Accident Prevention

Accident prevention is by far the best option for achieving a safe road transport system. The research area is defined in a strong link between the road users, the vehicles and the infrastructure.

Appropriately trained and behaving road users (**Human Factors**) are the most important part in this equation. Well-designed and operated roads (**Road Engineering**) that provide effective guidance to drivers and active safety systems in the vehicles (**Vehicle Technologies**) are technologies that complete the equation. Special attention needs to be given to the **Cooperative Systems** of communication between these different areas and to a safe interface between users and technology. **Accident Research** is the basis of understanding how and why accidents occur. This understanding is necessary for analysing the benefit of investment to optimise choices. The safety of new fuels along the production, distribution, usage chain needs to be assured (**Fuel Safety**).



SAFETY & SECURITY
Vision of a safe and secure road transport system
Expectations and Targets
Research Area Descriptions
3• Accident Prevention
4• Accident Impact Mitigation
5• Road Transport System Security

3.1 Accident Research

The key to avoiding road accidents and to mitigating the consequences of them is to know which combination of factors caused them. Accidentology is mandatory to get in depth information about both the accident mechanism and the resulting consequences and therefore can provide comprehensive insights for the identification of relevant accident counter-measures and their function. An important additional aspect of accidentology is the evaluation – a priori or a posteriori - of the effectiveness of these measures.

Understanding in this area is currently not complete, with only limited standard methodologies for information gathering and reporting. Clear “championship” is needed to establish harmonised European databases and analysis methodologies.

Accident Analysis

- There continues to be a significant requirement for real-world accident data. Research should focus on standardising the methodologies for real-world data collection: registration rates, injury classification, injury severity, quality guidelines, etc.
- Research should improve the analysis of real-world accidents, with particular reference to understand the pre-impact vehicle and occupant kinematics, impact of ageing society, demographical factors, changing car fleets and driver behaviour in critical situations.
- The contributions of accident analysis to several other areas in passive safety as dummies, crash tests, etc must be addressed in further research.
- Relationships between the driver, vehicle and road infrastructure characteristics must be analysed.

Methodologies for Accident Research

- Research must progress common methodologies at all levels in accident investigations, e.g. at the statistical as well as at the in-depth level.
- There is a need to further develop injury criteria and injury scaling:
  - Research should develop and introduce new injury criteria, e.g. neurological based,
  - Current criteria are based on the 'average' person and for the future criteria must be developed to represent age classes and genders.
- There is need for developing a European injury and impairment cost database together with the development of a common measure for cost of injury and fatality.
- Implementation of a European Safety Information System should be aimed at, with focus on:
  - Easy access to relevant data for all stakeholders,
  - Cross mode data availability,
  - Integration of new technologies in reporting systems,
  - Legal framework for data usage.

Reconstruction Methodologies

- Research for advanced accident reconstruction tools based on common methodologies is necessary.
- Reconstruction tools must be adapted to incorporate new data sources.

New Data Sources

- The benefits from supplementing existing accident data and analysis methods with information from existing sensors must be optimised.
- Developments towards enhanced in-vehicle and infrastructure data acquisition from existing and new systems should be advanced for accident and near-miss situation analysis.

Evaluation of the Effectiveness of Safety Measures

- Development of a generic evaluation methodology acceptable to all stakeholders is necessary.
- The impact of increased visibility of road and road equipment on user perception and accident rates must be assessed.
- Assessment studies of long-term behavioural adaptation towards new safety measures and technologies must be performed.
- Performance of freight restraining measures needs to be evaluated.

3.2 Human Factors

Road users, especially drivers, are a key link in the safety chain. Attention needs to be given to effective training, but also to understanding how people react in potentially hazardous situations.

Road User Education and Training

- Develop programmes to improve road user education and awareness, using safe driving principles accepted across different European countries.
- Driver training programs must be improved to:
  - Be attractive to the relevant driver groups,
  - Quickly respond to new vehicle technologies and how to interact with them,
  - Improve the driver's awareness of the system capability (e.g. ADAS systems),
  - Include more training on behaviour in critical situations.

Road User Behaviour and Status

- Understand human reactions to hazardous situations and develop methods for inducing appropriate behaviour.
- Research into the causes, frequency, detection and prevention of driver fatigue and drowsiness.
- Develop workload assessment for drivers in complex environments (signing, markings, ITS, warning, guidance, information) with the view to reduce this workload.

Integrated and Adaptive Human Machine Interaction (HMI)

- Develop an integrated and adaptive HMI minimising the level of workload and distraction for the driver.
- Research should determine the safe and reliable integration of users' electronic devices into road vehicles (e.g. PDAs, smart phones, navigation).

Driver Acceptance

- Develop information programmes to increase driver understanding and acceptance of new safety features and vehicle and infrastructure functions. Communication of the analysis of the socio-economic benefit needs to be included.

Technology Transfer

- Research should explore how to transfer best practise for technologies to between member states and to other countries.

Behavioural Adaptation

- Study the long-term behavioural adaptation to safety enforcements and other technologies.

3.3 Vehicle Technology

Research is needed on vehicle features that can help to avoid collisions. Potential contributions from these various technology areas are to be considered and integrated. Information Architecture (hardware-software) of the Intelligent and Interactive Vehicle must be defined and standardized as an open system, to allow the easy introduction of new functions as sensing and information technologies become available. A thorough understanding of driver reaction to complex systems will be needed.

Safety Functions

- Research is needed on Advanced Driver Assistance Systems such as lane and distance keeping, warning for inappropriate speed, longitudinal and lateral distance sensing for different kind of vehicles, smart active collision avoidance, and improved vision.
- Continued research on active safety measures to mitigate accident consequences once unavoidable (e.g. brake assist).
- Research is needed into methods of reducing accidents involving 2-wheelers and pedestrians. Improved visibility, traffic segregation and road user behaviour can all play a part.

▸ Research should contribute to solving potential conflicts of shared vehicle controls in driver assistance systems.

Actuation and Control

▸ Next generation active chassis dynamics including x-by-wire applications should be developed for improved driving behaviour and adaptive chassis control for weather-related road conditions.

Sensing and Recognition

▸ Develop and implement new sensor technologies (radar, laser, infrared, UV, electromagnetic...), positioning systems (GPS, GALILEO...), actuators and reliable software for preventing accidents (warning, assisting, controlling).

▸ Systems for improved vision in fog and darkness and intelligent hazard recognition must be developed.

Driver and Driving Monitoring

▸ Non-intrusive detection systems for health, fatigue or intoxication need to be developed.

▸ Research programmes are needed on driver attention and performance monitoring which focus on achieving reliable results.

Heavy Goods Vehicle Safety Issues

▸ Research to improve heavy goods vehicle safety must address compatibility, restraint systems, braking, stability and dangerous goods.

3.4 Cooperative Systems

Effective use of information, either generated locally by the vehicle-vehicle or vehicle-infra-structure system, or using global systems, offers improved information for the driver and the infrastructure management. Road safety will be improved through these information networks. Research is needed to understand governance issues and to identify effective methods for implementation within the road transport system.

Vehicle-Vehicle-Infrastructure Communication

▸ Co-ordinated development of infrastructure, vehicles and intelligent transport systems (ITS) is required to avoid lack of compatibility.

▸ Reduce the difficulties presented to the road user by the road environment through communication methods adapted to urban, interurban, local and rural conditions.

▸ For safety-critical locations, with a high incidence of accidents, research should address comprehensive eradication programmes based on communication and harmonised identification methodologies.

Cooperative Traffic Management

▸ More intelligent use of road infrastructure should be developed including electronic lane configuration, lane merging, controlled access to motorways and congested areas.

▸ New methods are needed to improve enforcement of regulations, traffic calming, and speed management, (geometrical, intelligent speed warning, etc.).

▸ Advanced traffic management systems, using two-way communication between road and vehicle are needed, allowing real-time traffic monitoring and information to road users.

Infrastructure Technologies

▸ Develop a European digital road map database, including safety information for road user support and warning (maximum speed, priority, road geometry, etc.).

▸ The potential for Automatic Vehicle Guidance that actively supports the driver in certain conditions needs to be developed.

▸ Validation and risk assessment methodologies to assure reliability of complex vehicle-road systems need to be developed.

3.5 Road Engineering

Good road design and construction can reduce accidents by reducing hazardous road geometry and by providing effective warning to drivers of approaching road features. There is also a need for improving the estimation of the cost of accidents used in the economic evaluation of road improvement options.

Road Layout and Controllability

- Improved intersection design, lane separation technologies, centre guardrails, and safer roadside areas can eliminate situations where small errors by the user lead to catastrophic consequences.
- New technologies for tunnelling and overpasses should be explored to construct dedicated lanes for truck and cars in order to avoid accidents caused by different types of vehicles interacting in the same traffic flow.
- Research is needed on safety arrangements and control during road works.
- New infrastructure design concepts and traffic calming measures to protect vulnerable road users (pedestrians, bicycles, seniors, children, disabled persons) need to be explored.

Road Marking and Signing

- Self-explaining road infrastructure is needed to provide drivers with effective warning of approaching road changes and hazards. Best practices need to be developed leading to a European harmonization of road infrastructure.
- New ways to signal road condition (weather conditions, fog, snow, ice, poor profiles, poor skidding resistance, aquaplaning) to the driver need to be researched.

Road Surface Technology

- Continued research is needed on more durable materials and technologies for road pavements, road marking etc., to reduce the need for maintenance and to guarantee high surface skid resistance level.
- Advanced materials and concepts are needed for more effective winter maintenance and ice prevention and prevention of summer time skid resistance problems.

Preparing for Change

- Evaluation is needed on how changes in climate or traffic require response in road engineering. Possible regional variations in design and construction must be explored.

Harmonisation of Processes

- Harmonisation of road safety audits and inspection procedures in order to identify corrective measures to potential risk hazards are to be developed.
- Develop auditing to assure safety outcomes from road improvement projects.
- Deploy a harmonised identification of dangerous road sections.

3.6 Fuel Safety

For conventional gasoline and diesel fuels, compressed natural gas (CNG) and liquified petroleum gas (LPG), fuel production, storage and distribution are achieved today with an acceptable degree of safety, through effective use of fuel specifications, handling procedures and infrastructure design.

Because of its potential importance as a future fuel, most of this section is devoted to hydrogen. Hydrogen is handled safely today in industrial situations, but presents unique new challenges if it is to be used by consumers. The properties of hydrogen differ significantly from those of gasoline or other conventional fuels. Therefore, a structured analysis of hazards and risks complemented by research is needed to support development of common regulations, codes and standards for both the vehicle and the fuel distribution system.

Codes and Standards

- Assess the current operating procedures and practices for handling both compressed and liquid hydrogen

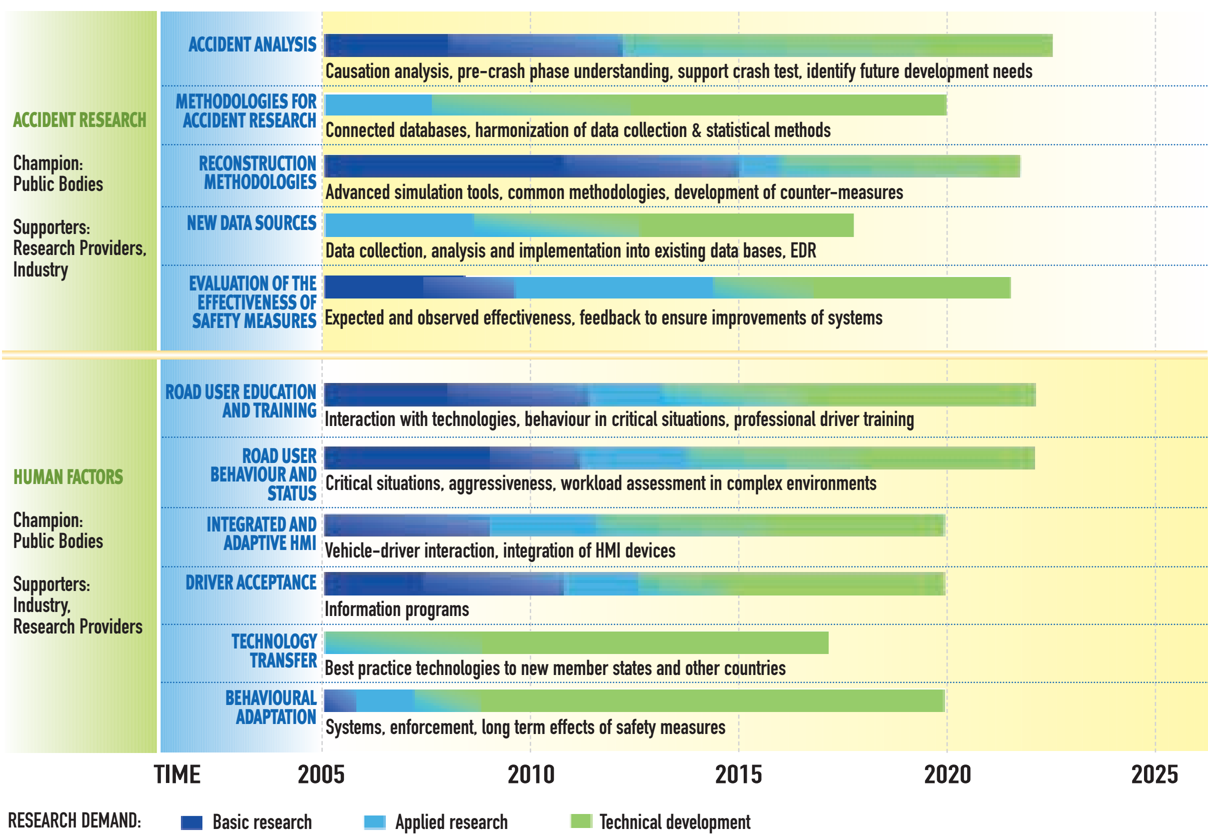
and develop towards harmonised codes or standards at European and global level, applicable in a bulk fuel market.

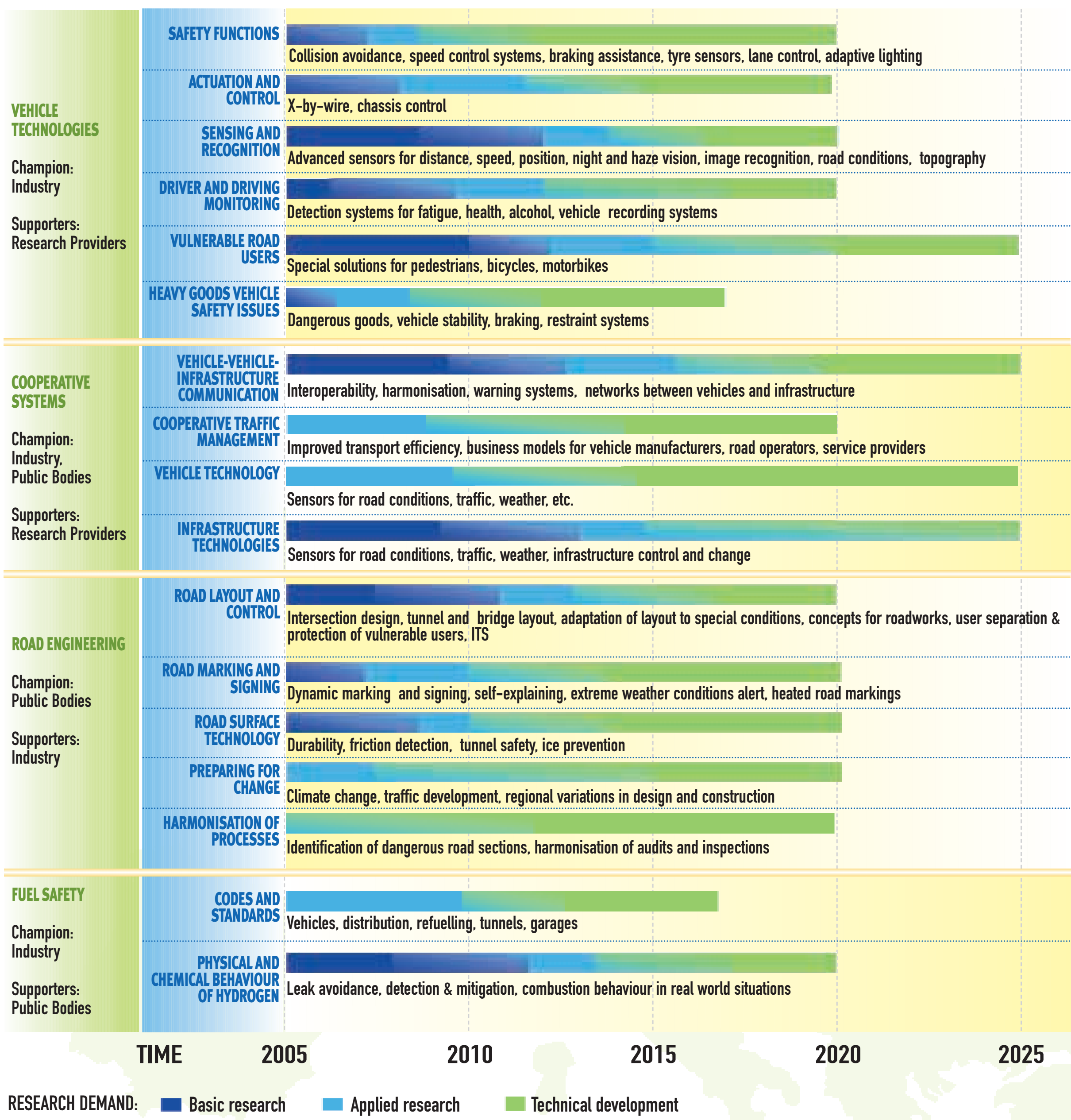
- Collect relevant data and harmonise risk analysis methodologies to ensure acceptable risk levels for hydrogen safety.
- Evaluate the safest ways for consumers to participate in the refuelling operation.
- Define specifications for hydrogen and other fuel cell fuels once the technical requirements are clear.
- Define standards for hydrogen storage and distribution systems, both on and off the vehicle.
- Assess the relative safety of direct hydrogen-fuelled fuel cell vehicles versus on-board reformers.

Physical and Chemical Behaviour of Hydrogen

- Understand how hydrogen fires behave in specific real-world situations such as filling stations, garages, tunnels and in the presence of other fuels.
- Understand flammability/detonation ranges for different ignition situations, and how to avoid geometries that may result in a detonation.
- Develop systems to minimise the risks of leakage in storage, use or vehicle fuelling.
- Develop odorants or other effective leak detection systems for hydrogen.
- Evaluate ways to handle boil-off from liquid H_2 storage in distribution or in vehicles.
- Define requirements for ventilation e.g. in garages, tunnels, to avoid risk of fire. Include consideration of cold liquid H_2 boil-off which may be heavier than air, as well as gaseous H_2.
- Determine the effect of exposure to hydrogen, in particular liquid H_2, on infrastructure including those constructed with newly developed materials.

Accident Prevention

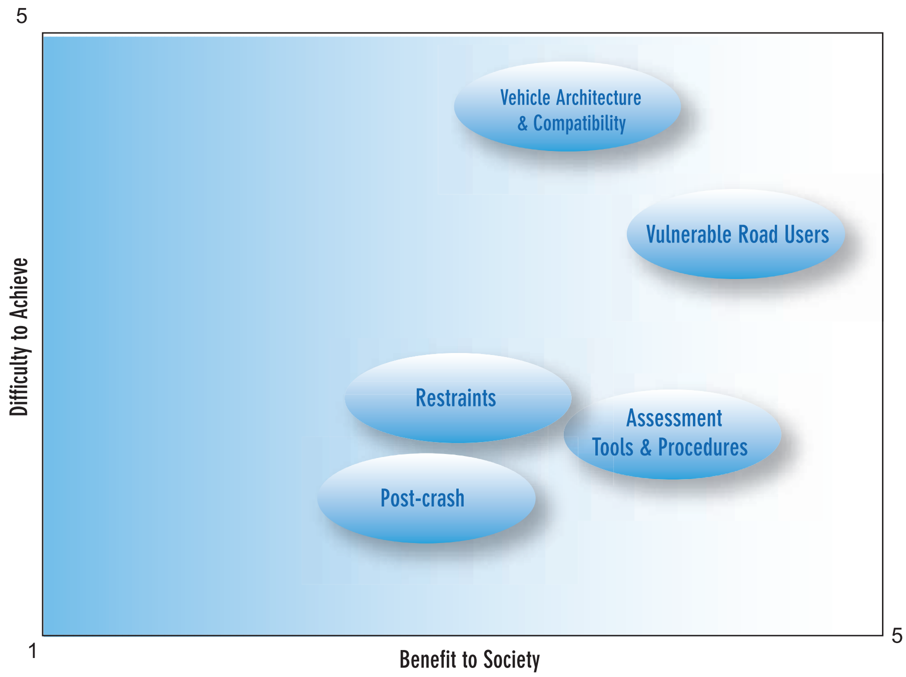




VEHICLE TECHNOLOGIES
Champion: Industry
Supporters: Research Providers
SAFETY FUNCTIONS
Collision avoidance, speed control systems, braking assistance, tyre sensors, lane control, adaptive lighting
ACTUATION AND CONTROL
X-by-wire, chassis control
SENSING AND RECOGNITION
Advanced sensors for distance, speed, position, night and haze vision, image recognition, road conditions, topography
DRIVER AND DRIVING MONITORING
Detection systems for fatigue, health, alcohol, vehicle recording systems
VULNERABLE ROAD USERS
Special solutions for pedestrians, bicycles, motorbikes
HEAVY GOODS VEHICLE SAFETY ISSUES
Dangerous goods, vehicle stability, braking, restraint systems
COOPERATIVE SYSTEMS
Champion: Industry, Public Bodies
Supporters: Research Providers
VEHICLE-VEHICLE-INFRASTRUCTURE COMMUNICATION
Interoperability, harmonisation, warning systems, networks between vehicles and infrastructure
COOPERATIVE TRAFFIC MANAGEMENT
Improved transport efficiency, business models for vehicle manufacturers, road operators, service providers
VEHICLE TECHNOLOGY
Sensors for road conditions, traffic, weather, etc.
INFRASTRUCTURE TECHNOLOGIES
Sensors for road conditions, traffic, weather, infrastructure control and change
ROAD ENGINEERING
Champion: Public Bodies
Supporters: Industry
ROAD LAYOUT AND CONTROL
Intersection design, tunnel and bridge layout, adaptation of layout to special conditions, concepts for roadworks, user separation & protection of vulnerable users, ITS
ROAD MARKING AND SIGNING
Dynamic marking and signing, self-explaining, extreme weather conditions alert, heated road markings
ROAD SURFACE TECHNOLOGY
Durability, friction detection, tunnel safety, ice prevention
PREPARING FOR CHANGE
Climate change, traffic development, regional variations in design and construction
HARMONISATION OF PROCESSES
Identification of dangerous road sections, harmonisation of audits and inspections
FUEL SAFETY
Champion: Industry
Supporters: Public Bodies
CODES AND STANDARDS
Vehicles, distribution, refuelling, tunnels, garages
PHYSICAL AND CHEMICAL BEHAVIOUR OF HYDROGEN
Leak avoidance, detection & mitigation, combustion behaviour in real world situations
TIME
2005
2010
2015
2020
2025
RESEARCH DEMAND:
Basic research
Applied research
Technical development

4• Accident Impact Mitigation

Once an accident becomes unavoidable, much can be done to minimise its effects. New "forgiving road" concepts are needed to mitigate the impact of road accidents. New vehicle safety technologies (**Restraints, Vehicle Architecture and Compatibility**) including intelligent passive and active safety devices as well as specific designs for **Vulnerable Road Users** are still needed to lower the seriousness of the accidents. Information management (**Post Crash**) has the potential to save precious minutes by providing automatic emergency calls and avoid follow-up accidents. **Assessment Tools and Procedures** should focus on improving biomechanical expertise for all types of human being. Injury mechanisms must be understood resulting into improving physical and virtual testing.



4.1 Vulnerable Road Users

Pedestrians and Cyclists

- Vehicle fronts should be developed that actively (through change) and passively (through shape and material) improve the safety of pedestrians and cyclists.

Mopeds and Motorcycles

- New types of roadside verges and protection systems for structures and road equipment are needed providing better protection in particular for two-wheelers.
- Smart equipment such as sensor-embedded road safety barriers, crash cushions, and soft pavement surfaces in urban areas that are capable of reacting to an impact should be developed and evaluated.
- Integrated safety systems for powered two-wheelers should be explored.

4.2 Assessment Tools and Procedures

Research should focus on improving biomechanical knowledge for a wide spectrum of body types, ages, and accident situations. Injury mechanisms must be understood resulting into improving physical and virtual testing. Infrastructure testing should be further developed to support the 'forgiving road' concept.

Biomechanics

- Research is needed to increase biomechanical expertise for all types of human beings: injury mechanisms, impact limits of body parts, etc.

‣ Developments towards standard biomechanical data formatting and harmonised experimental protocols must be strengthened.

Modelling and Virtual Testing

‣ Advanced human models need to be developed with active behaviour.
‣ Crash simulations must be improved including CAD-coupling to assess design modifications and their influence on safety issues.
‣ Models should be updated to include new materials, structures and joining techniques.

Dummy Development

‣ Further research is needed to create adequate motorcycle and pedestrian dummies and to improve crash test methods.
‣ The problem of side impact and dummy development needs inspired research.
‣ Research should investigate advanced materials that better mimic the behaviour of the human body.

Testing of Infrastructure Components

‣ Roadside elements (guardrails, barriers, verges) must be addressed in future safety developments and thus require standard, harmonised testing procedures.

4.3 Vehicle Architecture and Compatibility

Improvements in vehicle architecture and the compatibility among the vehicles can effectively mitigate the severity of accidents. Compatibility is understood as an optimisation of the combined self- and other protection. Research should focus on new materials and design as well as pre-crash sensing and activation of safety functions.

Impacts: Front, Side and Rear

‣ Research must continue on crash-worthiness, e.g. adaptive vehicle body structure with a special emphasis on side impact, impacts with small overlap and rollover.
‣ Energy absorbing structures and new lightweight materials are required in order to improve vehicle passive safety while reducing weight of the overall vehicle.
‣ Research into standardisation of vehicle front end to meet all legislative requirements for crash safety is needed.

Roll Over

‣ Research should develop systems that reduce the risk of skidding.
‣ An assessment methodology for rollover situations and severities is required.

Compatibility

‣ Accidents occur under all kinds of situations. Hence, research is needed to advance omni-directional vehicle crash compatibility.
‣ Possibilities for improvements of structural and geometrical compatibility to improve crashworthiness of impacts of different vehicles types must be identified.
‣ The definition of suitable test procedures needs to be developed.

Pre-crash Sensing and Activation

‣ Research is needed on Intelligent Passive Safety Systems, based on new sensor technologies, to detect unavoidable collisions and automatically activate protection systems to limit injuries.
‣ Significant developments are needed on numerical and experimental tools for the design and evaluation of Intelligent Passive Safety Systems.
‣ Pre-crash sensing systems for heavy-duty vehicles are required.

New Materials

- Considerable efforts should be made to better link the research landscape of material science to the one of passive safety.
- Research into crash performance of new materials, such as metallic foams composites, sandwiches, etc., and the development of corresponding simulation tools are required.
- A material aging and degradation effect on crashworthiness of a vehicle has to be considered.
- Adoption of new materials will also require research into more appropriate joining techniques.
- Research into new materials also needs to address the recyclability requirements.

4.4 Restraint Systems

Intelligent Systems

- Research on sophisticated, reliable and less aggressive occupant protection systems is needed including occupant sensing systems and adaptive protection systems that are tailored to vehicle occupants with respect to weight, size, position and special groups.
- The mechanism of the interaction between occupant and restraint system needs to be better understood to achieve best possible restraint performance and reduced 'out of position' related risks.
- Fusion opportunities of pre-impact sensing, avoidance systems and restraint systems must be identified and evaluated.

Interior Materials

- Developments in the field of smart materials and structures are needed to direct new solutions for interior design.

4.5 Post Crash

Post-crash situations can be improved by innovations for automatic sensing and warning of incidents. To avoid follow-up accidents and to improve the access for rescue vehicles research for dynamic queue management is needed. Improved trauma treatment is required to alleviate accident consequences.

Automatic Sensing and Warning

- Further development, implementation and evaluation of the European emergency call and the in-vehicle emergency calls are needed to optimise data requirements and transmission systems.
- Detecting the occurrence of a serious crash and automatic notification of the emergency services of the location and severity of the crash and the number of occupants involved must be enhanced.
- Innovations are also needed for detection and warning of incidents (congestion, road works) and avoidance and management of queue formation.
- To avoid follow-up accidents and to improve the access for emergency vehicles dynamic traffic flow management and speed control systems need further progress.

Rescue Procedures

- Focus should be given to research which delivers optimised cooperation between all actors.
- Investigate the potential benefits of biometric sensor technologies and other related technologies to aid rescue services and subsequent medical treatment.

Trauma Logistics and Treatment

- Improved accident trauma management that is linked to intelligent transportation systems is required in order to alleviate accident consequences. Coordination among all services is key for improvement here.
- Focus should be given to improve trauma care in rural areas as emergency response times are longer and standards of initial care can be lower.

Accident Impact Mitigation

Area	Topic	Research content
VULNERABLE ROAD USERS Champion: Public Bodies Supporters: Industry	PEDESTRIANS AND PEDAL CYCLISTS	Safer vehicle fronts – active & passive
	MOPEDS AND MOTORCYCLES	Leg & torso protection, verges, guide rails
ASSESSMENT TOOLS & PROCEDURES Champion: Industry Supporters: Research Providers	BIOMECHANICS	Injury mechanisms, impact limits of body, biomechanical databases, modelling
	MODELLING AND VIRTUAL TESTING	Improved human models and virtual testing
	DUMMY DEVELOPMENT	Motorcycle and pedestrian dummy, test methods
	TESTING OF INFRASTRUCTURE COMPONENTS	Roadside elements (barriers and verges), crossing layouts
VEHICLE ARCHITECTURE AND COMPATIBILITY Champion: Industry Supporters: Research Providers	IMPACTS - SIDE, REAR, FRONT	Standards, energy absorbing structures
	ROLL OVER	Assessment methods, reduction of skidding risk
	COMPATIBILITY	Vehicle crash compatibility, external airbags
	PRE-CRASH SENSING AND ACTIVATION	Sensors, object recognition including pedestrians, braking assistance
	NEW MATERIALS	Multi-material composites, high strength materials, crash performance, joining technologies
RESTRAINT SYSTEMS Champion: Industry Supporters: Research Providers	INTELLIGENT SYSTEMS	Detection of occupants & seating position, adaptive systems
	INTERIOR MATERIALS	Structural and geometrical adjustments
POST CRASH Champion: Public Bodies Supporters: Industry	AUTOMATIC SENSING AND WARNING	Activate emergency services, information on accident severity, location, passengers, dangerous goods
	RESCUE PROCEDURES	Response scenarios, optimised cooperation, navigation of rescue vehicles, "Blue Corridor"
	TRAUMA LOGISTICS AND TREATMENT	Enhanced coordination of all services, trauma care in rural areas

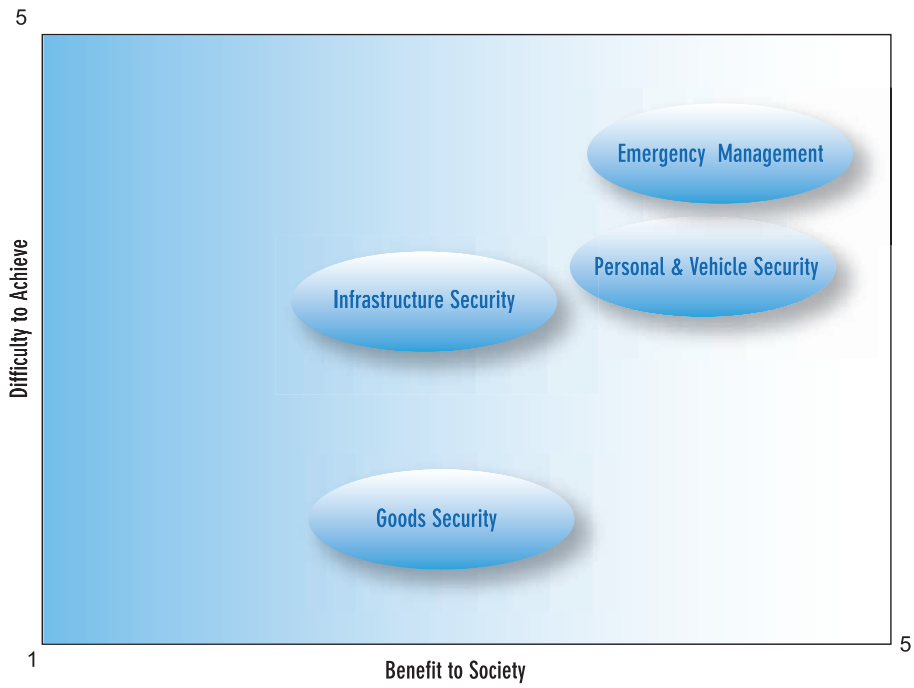
TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research | Applied research | Technical development

■ SAFETY & SECURITY
Vision of a safe and secure road transport system
Expectations and Targets
Research Area Descriptions
3• Accident Prevention
4• Accident Impact Mitigation
5• Road Transport System Security

5• Road Transport System Security

Accidents and other threats require additional improvements in **Emergency Management**. Accidents are not the only threat faced by road users. The threat of attack can be a deterrent to vulnerable travellers, and theft of vehicles or goods presents a serious economic loss to the community (**Personal and Vehicle Security**). There is a need for improved anti-theft systems and for development of information systems to track vehicles and goods and hence deter crime (**Goods Security**). New methods for **Infrastructure Security** will ensure safety for all.



5.1 Emergency Management

Another area of development is security issues related to special events.

Evacuation and Rescue

- Databases to identify the nature and magnitude of the security problems in road transport are required.
- Mayday and emergency evacuation management procedures and systems should be further developed and optimised.

Prevention Measures

- Additional prevention measures for hijacking and vandalism are needed.
- Prevention and identification of vehicle use for terrorist attacks should be elaborated.

5.2 Personal and Vehicle Security

Identification and Recognition

▸ A wide range of research on security systems should be developed based upon user needs to respond to new challenges in security such as:
▸ Thief deterrent systems,
▸ Personal safety systems (e.g. based on biometrics),
▸ Automatic car identification and monitoring through secret personal chip, recorded when ownership changes,
▸ Automatic linkage between car and driver registration, e.g. driving license tag used for vehicle ignition.

Security-designed Vehicle

▸ Coding of parts/devices used in the vehicle by original equipment manufacturers (OEMs) enabling the tracking of stolen parts and avoiding misuse of stolen parts
▸ New materials such as laminated side glazing are required.
▸ Design concepts of systems for public transport vehicles that improve both real and perceived personal security concerns.

Advanced Tracking Technologies

▸ Vehicle tracking technology and systems require additional development.

5.3 Infrastructure Security

Secure Communication and Information Network

▸ Research is needed to achieve systems for communication and information that are secure and interoperable.

Advanced Surveillance and Protection

▸ Better integration of monitoring, surveillance and response systems into traffic management and infrastructures, including intermodal points is necessary.
▸ Advanced concepts for remote monitoring systems for infrastructure, road-users and goods security must be explored.

5.4 Goods Security

Theft Prevention

▸ In a similar manner, new challenges and opportunities on goods security need to be addressed with respect to tracking, tracing, monitoring and response technologies e.g. load identification, to address main types of issues as:
▸ Theft of vehicles,
▸ Theft from vehicles,
▸ Theft of goods from warehouse or intermodal node.

Dangerous Goods

▸ Risk management needs to be developed for the transport of hazard and safety-critical goods, including precise tracking of such goods and specific strategies for emergency scenarios.

Road Transport System Security

EMERGENCY MANAGEMENT Champion: Public Bodies Supporters:	EVACUATION AND RESCUE	Response scenarios, scalable systems, standardisation, optimised cooperation
	PREVENTION MEASURES	Situation adapted – hijacking, vandalism, terrorist attacks
PERSONAL AND VEHICLE SECURITY Champion: Industry Supporters: Research Providers	IDENTIFICATION AND RECOGNITION TECHNOLOGIES	Biometric, e-authentification, recognition sensors, personalisation, personal chip
	SECURITY-DESIGNED VEHICLE	Demobilisers, materials, coding of parts
	ADVANCED TRACKING TECHNOLOGIES	Automatic positioning, automatic car identification in criminal acts
INFRASTRUCTURE SECURITY Champion: Public Bodies Supporters: Industry	SECURE COMMUNICATION AND INFORMATION NETWORKS	Space based observation & communication
	ADVANCED SURVEILLANCE AND PROTECTION	Sensors, IT, intermodal points
GOODS SECURITY Champion: Industry Supporters:	THEFT PREVENTION	Secure vehicles, logistics centres, intermodal nodes, load identification and tracking, sealing
	DANGEROUS GOODS	Hazardous and exceptional goods standardisation, best practices across Europe

TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research, Applied research, Technical development

ENVIRONMENT, ENERGY, RESOURCES

Vision of a cleaner, quieter and more energy efficient road transport system

MAJOR ASPECTS OF THE ERTRAC VISION 2020:

- Greenhouse gas emissions and energy use from individual vehicles have been substantially reduced thanks to a wider use of highly fuel-efficient vehicles and increasing use of improved conventional, renewable and alternative low carbon fuels where beneficial to the environment. Efforts are continuing to achieve further improvements in the longer term.
- Renewable and alternative low-carbon fuels together with advanced vehicle powertrains begin contributing to environmental improvement and security of energy supply. Their large-scale availability and distribution infrastructure is still a challenge in 2020.
- The transport system has become more efficient minimising road traffic congestion contributing greatly to reducing the energy consumption of individual road vehicles.
- Emissions other than CO_2 from new road vehicles, including two-wheelers, over their entire life cycle are at levels that have negligible impact on air quality.
- Noise from the road traffic system has been reduced. Noise levels are appropriate to individual locations including quiet zones.
- Vehicle manufacturing systems and road construction and maintenance processes are designed to maximise the extent of recycling. Advanced technologies allow a substantially more efficient use of resources and energy.
- Road transport energy use and resources approach sustainable levels.
- Due to new cleaning and protection technologies, the impact from surface run-off on water quality is minimal.
- New approaches to the road transport system are minimising environmental impacts on communities and natural habitats.

Expectations and Targets

In the past decades, public health concerns were raised over emissions from road vehicles and their impact on air quality. Today, emissions from new vehicles are a small fraction of what they were 20 years ago, and fleet emissions are reducing substantially as older vehicles are replaced. Although some concerns remain, for example particulate and NOx emissions, it is a realistic expectation that by 2020, pollutant emissions from road vehicles including two-wheelers will be near zero with no negative impact on air quality. One remaining task may be to manage local urban emission spots, including the remaining small fraction of "high emitting" vehicles.

The European Union has agreed to the Kyoto Protocol target to reduce greenhouse gas (GHG) emissions by 8% in the period 2008-2012 versus the 1990 baseline. In the area of transport, the Commission has set a target of 20% substitution by alternative road fuels by 2020, driven by concerns over energy security and GHG emissions. Some of these topics, especially GHG emissions, must be treated as global issues.

The research challenge is to deliver low emissions while also meeting individual and societal demands for mobility, vehicle performance, reductions in GHG emissions and improvements in energy efficiency. Reducing GHG emissions from road transport is a particular challenge given the anticipated demand growth of around 32% in passenger kilometres by 2020, and 69% in tonne kilometres[8]. The evaluation of future fuel and vehicle options and the choice of the most promising pathways need to be based on strategic studies, including the established well-to-wheels analyses.

The FURORE programme estimates that improvements in vehicle efficiency and CO_2 emissions (a 40% reduction, equivalent to 95g/km fleet average) are feasible for new passenger cars in 2020, with 10% improvement for heavy duty (HD) trucks and 40% for buses. The result would be a 30% reduction in average CO_2 emissions for the new vehicle fleet in 2020. A number of alternative powertrains and fuels are being actively developed that have the potential to deliver benefits in 2020 and beyond, provided sustained research efforts are begun now. In addition, good vehicle maintenance and driving for economy by changing gear early, good anticipation and avoiding excessive speed can reduce fuel consumption and CO_2 emissions by at least 10% for cars and 5% for HD vehicles[9].

Improvements in the design and maintenance of road infrastructure, better surfaces and selective upgrades, best use of transport modes and information technology systems, together with higher passenger car occupancy rates and freight loads, can also contribute to free-flowing traffic with further reductions in fuel consumption (10-20%).

The current interest in GHG emissions and energy efficiency highlights the need to consider the vehicle and fuel as a system. Hydrogen fuel cell vehicles produce no emissions of CO_2 or other GHGs at the point of use, but efficient processes are needed to produce the hydrogen fuel and deliver it to the vehicle. Well-to-wheels analyses are an essential tool to evaluate alternative fuels and powertrains and choose the best pathways.

[8] EU Energy and Transport Outlook to 2030.
[9] http://www.aida.utwente.nl/onderzoek/onderzoekspublicaties/voort.pdf
http://www.scania.com/about/environment/Driver/

Fuel pathways that produce low GHG emissions on a well-to-wheels basis could complement more efficient vehicles leading to partial decarbonisation of the fuels pathway. Advanced biomass fuels, including those based on gasification or cellulosic fermentation, are promising and deserve further development. Fuels derived from wind or solar electricity may contribute in the longer term. For all renewable fuel options, the GHG gains need to be balanced against the likely greater savings that could be made by substituting other energy supplies such as power generation. Well-to-wheels analyses can again help identify the best choices.

Traffic growth in the developing world means that the contribution of Europe to world energy use and GHG emissions is decreasing in percentage terms. Consideration should therefore be given to how new technologies can be applied in areas of the world where the cost and complexity of modern vehicles may be a challenge.

Maintaining low emissions over the vehicle lifetime is already a priority. By 2020, Euro-5 & 6 emissions standard vehicles and 10ppm sulphur fuels will be well established in the European market. In-use emissions compliance should be handled by advanced on-board diagnostic systems. Other impacts of road transport also require attention, including transport noise and groundwater quality. Sustainable use of resources and design-for-environment concepts will enable further environmental improvement.

Transport planning can also affect emissions from the transport system. Reduced traffic congestion will reduce energy consumption and emissions. In terms of the road infrastructure, energy recovery from the road could be sufficient for its own energy needs (signalling, lighting, etc.), allowing cooling of the pavements in the summer and heating them in the winter.

Specific Research Targets are:

- Improvements in vehicle efficiency will deliver as much as a 40% reduction in CO_2 emissions for passenger cars and 10% for heavy duty vehicles for the new vehicle fleet in 2020[10].
- Good vehicle maintenance and driving for fuel efficiency will reduce fuel consumption and CO_2 emissions by at least 10% for cars[11] and 5% for heavy duty vehicles[12].
- Improvements to the road transport infrastructure, best use of transport modes, information technology systems, higher passenger car occupancy rates and freight loading factors will contribute to further reductions in fuel consumption by 10-20%.
- Further reductions of carbon emissions associated with fuel production will be achieved[13].
- By 2020, fuel cell vehicles and low carbon / hydrogen fuels will begin contributing to carbon reduction provided sustained research efforts are begun now.
- By 2020, Euro-5 & 6 emissions standard vehicles will be well established in the vehicle fleet. The research target is to achieve these near zero emissions levels at minimum cost while still improving energy consumption and CO_2 emissions.
- Transport noise will be reduced by up to 10 dB(A) through a systems approach including better indicators and improvements to vehicles, tyres and infrastructure.
- Sustainable use of resources and recycling of vehicles and road infrastructure materials will also contribute to the preservation of the environment.

[10] FURORE: Future Road vehicle Research, R&D Technology Roadmap. October 2003.
[11] http://www.aida.utwente.nl/onderzoek/onderzoekspublicaties/voort.pdf
[12] http://www.scania.com/about/environment/Driver/
[12] Well-to-wheels analysis of future automotive fuels and powertrains in the European context. Published by JRC, EUCAR and CONCAWE, January 2004

Research Area Descriptions

In order to provide a meaningful framework, the Research Area Descriptions are structured to support two core goals:

6• Reduced GHG Emissions and More Efficient Energy Use
7• Environment, including Impact on Communities and Natural Habitats

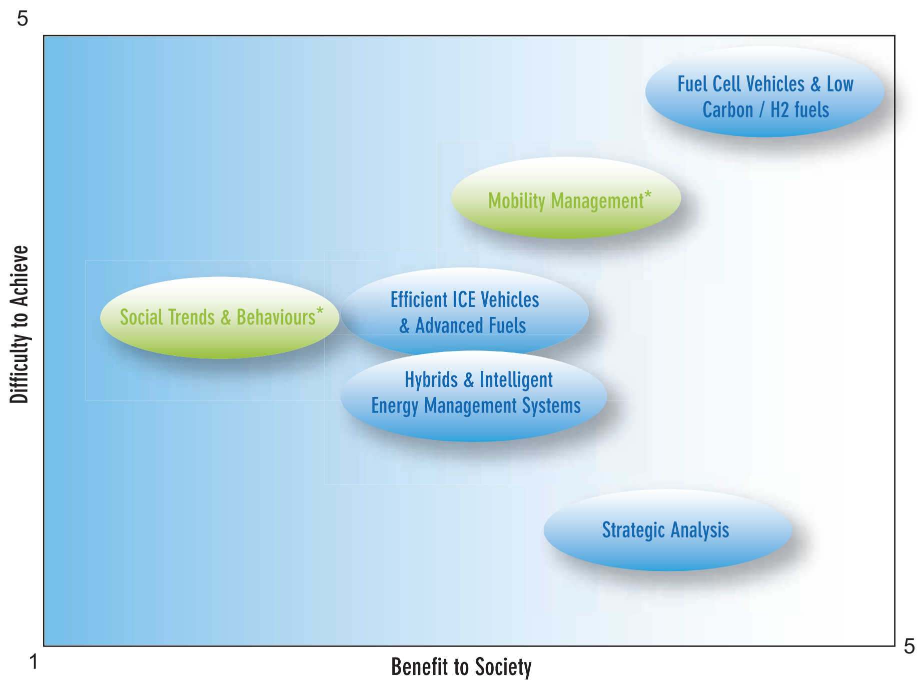
Each of these goals is then addressed through a set of technology-based objectives. The GHG goal has such a wide scope that strategic analysis will also be required to select the set of solutions which are most acceptable from technical, economic and social perspectives.

6• Reduced GHG Emissions & More Efficient Energy Use

Motor vehicles (cars, trucks, buses, motorcycles) provide a major part of our road transport needs. The effectiveness with which vehicle and fuel technologies provide this service therefore has a direct impact on energy use and emissions. At the same time, lower GHG emissions need to be achieved without negating the substantial progress that has been achieved in improving air quality as a result of lower vehicle emissions. Improved vehicle performance will also be supported by minimising traffic congestion, which reduces emissions, in addition to its direct benefits for road travellers. Synergistic effects from transport planning, road infrastructure and ITS systems development will all play a part.

To identify the best options, the vehicle, fuel and infrastructure need to be considered as a system, using well-to-wheels analysis and economic assessments to find the most effective ways to reduce regulated emissions and GHGs. Planning and modelling tools are required to track progress and forecast future issues and needs.

In the time period to 2020, the main improvements in energy use and GHG emissions will come from **Efficient Internal Combustion Engines (ICE)**, and their associated **Advanced Fuels**. **Hybrids and Intelligent Energy Management Systems**, will be an important associated technology. Research is also needed on



** Some research topics appear under more than one objective; the "Benefit to Society" in each case refers to the specific research objective for that chart. See SRA Development process for further information.*

Hydrogen and Fuel Cell Vehicles, although these will not make a significant contribution in the market until after 2020. **Strategic Analysis**, including well-to-wheel studies will be important to make the right technology choices. Energy use will also be influenced by **Mobility Management**, including high quality infrastructure and use of ITS to ease traffic flow, and by **Social Trends and Behaviours** which may impact transport demand and fuel-efficient driving

6.1 Strategic Analysis

- Analysis is needed to understand changing demographics and transport needs, to guide transport infrastructure and technology development and provide input for demand planning. Effective transport planning should help achieve an optimum transport mix, reduce fuel consumption and emissions.
- On-going well-to-wheels analysis is needed to evaluate improved conventional and newly developing vehicle and fuel technologies. The analysis must also identify those options that provide the best energy savings, GHG reductions and economic feasibility.
- Investigations are needed into the best uses of biomass and optimum use of available land since the total resource available is limited.
- Construction of updated emissions inventory models and road transport emissions forecasting tools, interfaced with atmospheric dispersion and chemical transformation models, is needed to understand the impact of implementation of new technologies.
- Methodologies are needed for a systems approach to new technologies such as HCCI/CAI including the vehicle, fuel and lubricant, and considering the infrastructure/customer acceptance aspects where new fuels are considered.
- The capture and storage of CO_2 during central fuel processing or use requires technical and economic feasibility studies. Current proposals include re-injection into depleted oil or gas wells, or deep ocean storage.
- Renewable energy supplies will be limited for the foreseeable future. Research is needed on how they may be best employed (e.g. for power generation or niche markets) to achieve the maximum GHG and energy savings.
- Innovative infrastructure designs are needed including segregated traffic flow and effective use of technology for information and traffic management to ensure optimum use of the existing infrastructure.
- Research is needed on what influences acceptability of new technologies to the consumer, and how technologies can be effectively introduced.
- Research is needed on better metrics (e.g.; energy use/GHG emissions per person-km or per payload tonne) and how to maximise vehicle occupancy and efficiency based on these new metrics. This work needs to integrate with studies to decouple consumer needs from vehicle km travelled (see Mobility section).
- Research is needed on how solutions originally designed for Europe can be effectively modified for application in other world areas, and conversely, on learning from innovations developed outside of Europe.
- Ways need to be explored to ensure that vehicles deliver their maximum efficiency through driver education, improved transmissions, information to the driver or an environmental OBD, avoidance of “chip-tuning”, and improved inspection and maintenance.
- Regulated test cycles must continue to be representative of real-world vehicle operation, and vehicles must be able to perform well under all operating conditions.

6.2 Efficient ICE Vehicles and Advanced Fuels

Advanced Internal Combustion Engines

- Further development is needed on advanced ICE systems. Research items which have potential to contribute to higher efficiency and lower engine-out emissions include: flexible powertrain components, advanced fuel injection, boosting, lean operation, high specific torque, downsizing and variable systems (valve timing, compression ratio etc.)
- Improved efficiency of natural gas engines could increase the interest in of this fuel.

- The potential of hydrogen ICEs also needs to be further studied and compared with direct hydrogen fuel cell technology.
- Further development is needed on Advanced Vehicle Design Tools (including CAD).

New Combustion Concepts

- New combustion concepts such as HCCI, CAI, and integrated combustion processes, perhaps assisted by new fuels, offer the potential to achieve high efficiency coupled with low emissions.

Fuels and Lubricants for Advanced ICEs

- Sulphur-free fuels are currently being introduced to enable the next generation of engines/after-treatment systems to achieve low emissions and best efficiency. Development of more cost effective processes for production and supply of sulphur-free fuels will continue to be needed.
- R&D into further improvements in crude oil processing is needed to minimise GHG emissions associated with fuel production.
- Further developments in fuels associated with new engine developments may provide opportunities for further improved efficiency and lower GHG emissions from Internal Combustion Engines (ICE).
- Further developments in fuel additives are likely to be needed in order to achieve near-zero emissions vehicles with long-term durability.
- Advanced lubricants for advanced engines need to be developed in a systems approach.
- Evaluation is needed of the most effective ways to integrate natural gas into transportation with respect to local availability, emissions, energy use and cost.
- Fischer-Tropsch (F-T) diesel fuel provides a high quality blending component that could extend Europe's diesel production capacity, but it requires additional cost reduction to be competitive in European markets.

Improved Design Elements

- Improved and more cost effective components including batteries, control systems, lightweight materials and low friction lubricants are needed to support new ICE developments.
- Advanced combustion systems will require effective and durable NOx control under lean conditions, and control of particulate matter.
- Advanced transmissions and control systems are required to enable the engine to operate in the most efficient part of the speed/load range.
- New materials and processes are necessary for vehicle mass reduction and associated improvements in fuel consumption.
- Reduced friction through design improvements together with advanced lubricants and new surface treatments requires further investigation.
- New infrastructure concepts could offer reduced rolling and aerodynamic losses through modification of the road profile and road environment. This also includes improved wet weather performance and appropriate maintenance.
- Further developments in aerodynamics and tyres for low rolling resistance are desired while maintaining high levels of vehicle safety and optimum performance. This requires advanced modelling and simulation tools.
- Advances in sensors are needed to improve on-board diagnostics and monitoring of real-world performance.

Biomass Derived Fuels and Fuels from Waste

- Research is needed on more efficient and affordable ways of capturing and recovering solar energy via biomass.
- Investigation is needed of the best use for biomass since the amount of waste or purpose grown biomass available for fuel use is ultimately limited.
- Opportunities to improve the energy and GHG efficiency of those processes leading to ethanol or Fatty Acid Methyl Esters (FAME) should be explored, for example by effectively utilising all the biomass produced.
- Alternative processes that could potentially give higher yields by converting woody and grassy materials to ethanol, or by gasification leading to a range of fuel products should be studied, and their benefits compared with alternative uses for biomass, such as direct heat and power generation.
- Advanced biomass fuels, including gasification or cellulosic fermentation, may offer higher GHG savings than are possible with today's biofuels. Opportunities for production of multiple products should be

investigated. Studies need to include the impact of scale of the most efficient processes balanced against the dispersed nature of biomass supplies.
- The production of biomass fuels needs study to quantify the overall environmental impact including land use, genetically modified (GM) crops, biodiversity and water quality.
- Expanded opportunities for use of waste should be explored. This can include waste biomass materials, but also other waste such as plastics or city waste.

6.3 Hybrids and Intelligent Energy Management Systems

Hybrid Technologies
- Hybrid vehicle concepts use the energy produced by the engine more efficiently, but require development to simplify designs, better integrate the IC engine and electric drives to reduce cost and improve performance over the entire driving range.
- Research is needed to maximise the benefits of 'mild' hybrid concepts and technologies.
- The potential for engine downsizing to further improve efficiency while maintaining acceptable customer performance should be investigated.

Improved Components
- Research is needed to improve energy storage media and devices, batteries, materials, auxiliaries, electric motors, intelligent energy management and control systems in order to optimise fuel consumption in real operating conditions.

Vehicle Energy Management
- Advances are needed in air conditioning and cooling systems.
- Advanced transmissions and integrated operations offer additional opportunities for improvement.

In-use Performance
- Real-world performance of advanced vehicles including hybrids needs to be assessed.
- Developments of advanced sensors are needed to improve on-board diagnostics, monitor of real-world performance and prevent tampering.

Advanced Traffic Management
- Intelligent systems should be developed to reduce energy use through driver assistance and improved traffic management.

6.4 Fuel Cell Vehicles and Low Carbon/Hydrogen Fuels

The principal elements of the SRA for fuel cell vehicles and hydrogen are given below. A more detailed version is being developed as part of the European Hydrogen and Fuel Cell Technology Platform.

Fuel Cell Technologies
- Key performance challenges are dynamic response, efficiency, durability, cost and ability to operate over a wide temperature range.
- New substrates with enhanced performance characteristics and better catalysts are needed to improve durability and reduce cost.
- Research is needed on higher temperature PEM membranes, bipolar plates, air systems and humidity management to improve performance and cost of fuel cell systems.

Fuel Cell Vehicles
- The performance of fuel cells in real vehicle applications needs to be clearly documented, and strategies developed to maximise the real-world efficiency and well-to-wheels benefits.
- Significant improvements in vehicle cost, performance and reliability are needed to achieve customer acceptance.

- Safety of all aspects of hydrogen fuel systems and vehicles needs to be assured for large-scale market penetration.
- Research is needed on auxiliary power units (APUs) as well as on full propulsion systems which may open opportunities for solid oxide fuel cells (SOFC) as well as proton exchange membrane (PEM) fuel cells.

Hydrogen Production from Non-fossil Sources

- For direct hydrogen applications high volume, cost-effective, energy efficient, and low GHG production methods for hydrogen production need to be developed and proven.
- Research is needed to define a long-term hydrogen supply strategy, and develop appropriate technologies.
- Cost effective processes for large-scale hydrogen production from biomass, wind and other renewable energy sources are needed.
- The acceptability of nuclear power as a low-carbon source of electricity and hydrogen needs further evaluation.

Hydrogen Production from Hydrocarbons

- Further improvements for large and smaller scale distributed production of hydrogen from natural gas and other hydrocarbons in terms of efficiency, GHG emissions and cost are needed.
- Hydrogen reformer technology, including on-board systems, must be further explored to improve efficiency and reduce cost, size, and start-up time.
- Efficient, safe and cost-effective means of capturing and storing of CO_2 during central fuel processing need to be developed.

Hydrogen Storage on Vehicles

- Low cost, high capacity hydrogen storage is needed, both chemical and mechanical.
- Safety systems including monitoring of leaks need to be defined.

Hydrogen Distribution Infrastructure

- Handling, transportation and dispensing hydrogen need to be proven in small-scale fleets.
- New standards are required to ensure safe production, storage, distribution and end-use of hydrogen.
- Safety of all aspects of hydrogen fuel systems and vehicles needs to be assured before widespread implementation is considered.

6.5 Mobility Management

- Improved traffic management (see the Transport and Mobility section for specific research topics) will reduce congestion and thus reduce road transport emissions.
- Innovative infrastructure design, for improving traffic flows, protecting the environment from noise, and capturing and treating emissions from road traffic should be developed.
- Road infrastructure has considerable potential for energy recovery. Different systems should be explored such as solar energy, traffic flow windmills, Peltier elements, piezoelectric elements, heat exchange systems and heat pipes for collecting heat from the pavement in the summer and returning heat in the winter. This would decrease the use of de-icing salts and increase safety and pavement lifetime.
- Consideration is needed on the application of telematics to maintain smoother traffic flow and optimise the transport system, including increased passenger car occupancy rates, freight loading, and use of non-motorised modes.

6.6 Social Trends and Behaviours

- Studies are needed into driver behaviour and impact of regulatory measures in order to encourage more efficient driving and influence transport mode selection.
- Vehicle and road technologies that can contribute to fuel efficient driving patterns should be evaluated.
- Studies are needed into means to reduce growth in demand for personal mobility and transport of goods while maintaining economic and social well-being.

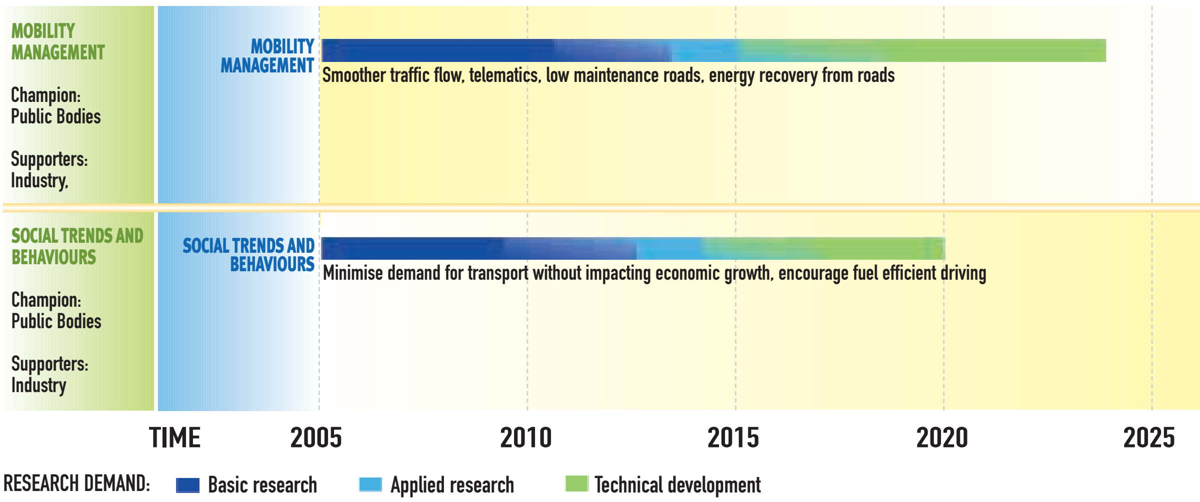
GHG Emissions / Efficient Energy Use

Research area	Topic	Description
STRATEGIC ANALYSES Champion: Public Bodies Supporters: Industry	SYSTEMS APPROACH TO VEHICLE, FUEL, INFRASTRUCTURE	Well-to-wheels analysis, optimised land use, renewable energies, infrastructure and demand planning, customer acceptance, integrated modelling and forecasting tools interfaced with atmospheric models
EFFICIENT, ICE VEHICLES & ADVANCED FUELS Champion: Industry Supporters: Public Bodies, Research Providers	ADVANCED IC ENGINES	High specific torque, flexible components, advanced fuel injection, downsizing, boosting, lean operation, variable systems, optimised natural gas engines, CAD tools
	NEW COMBUSTION CONCEPTS	Extended homogeneous range in diesel engines, controlled auto-ignition, integrated combustion process, low engine-out emissions
	FUELS AND LUBRICANTS FOR ADVANCED ICES	Sulphur-free fuels, adapted fuels for new combustion processes, GTL, additives for advanced fuels/engines, advanced lubricants and reduced lube oil consumption
	IMPROVED DESIGN ELEMENTS	Control systems, batteries, materials, low friction engines/lubricants, tyres, lightweight vehicle components, cost reduction, packaging
	BIOMASS DERIVED FUELS	Optimised land use, BTL, step-out bimass technologies
HYBRIDS & INTELLIGENT ENERGY MANAGEMENT SYSTEMS Champion: Industry Supporters: Public Bodies, Research Providers	HYBRID TECHNOLOGIES	System simplification and integration, cost reduction, specialised hybrid components
	IMPROVED COMPONENTS	Control systems, energy storage (batteries, ultra-capacitors), materials, electric motors
	VEHICLE ENERGY MANAGEMENT	Air conditioning, cooling, advanced transmissions and integrated operations
	IN-USE PERFORMANCE	Advanced sensors, improved OBD, OBM, real-world performance, anti-tampering
	ADVANCED TRAFFIC MANAGEMENT	Driver assistance, navigation aids, human-machine interface, robotics, ITS
FUEL CELL VEHICLES AND LOW CARBON / HYDROGEN FUELS Champion: Industry Supporters: Public Bodies, Research Providers	FUEL CELL TECHNOLOGIES	High temperature membranes, bi-polar plates, air systems, humidity management, low weight, low cost, high efficiency, durability
	FUEL CELL VEHICLES	APU, full propulsion systems, on-board reformers
	HYDROGEN PRODUCTION FROM NON-FOSSIL SOURCES	Biomass, renewables, nuclear electricity
	HYDROGEN PRODUCTION FROM HYDROCARBONS	Efficient NG / liquid fuel conversion, carbon capture and storage
	HYDROGEN STORAGE ON VEHICLES	Low cost, high capacity storage (chemical & mechanical), safety and monitoring systems
	HYDROGEN DISTRIBUTION INFRASTRUCTURE	Handling, transportation, dispensing

TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research · Applied research · Technical development

ENVIRONMENT, ENERGY, RESOURCES
- Vision of a cleaner, quieter and more energy efficient road transport system
- Expectations and Targets
- Research Area Descriptions
  - 6• Reduced GHG Emissions and More Efficient Energy Use
  - 7• Environment - Including Impact on Communities and Natural Habitats



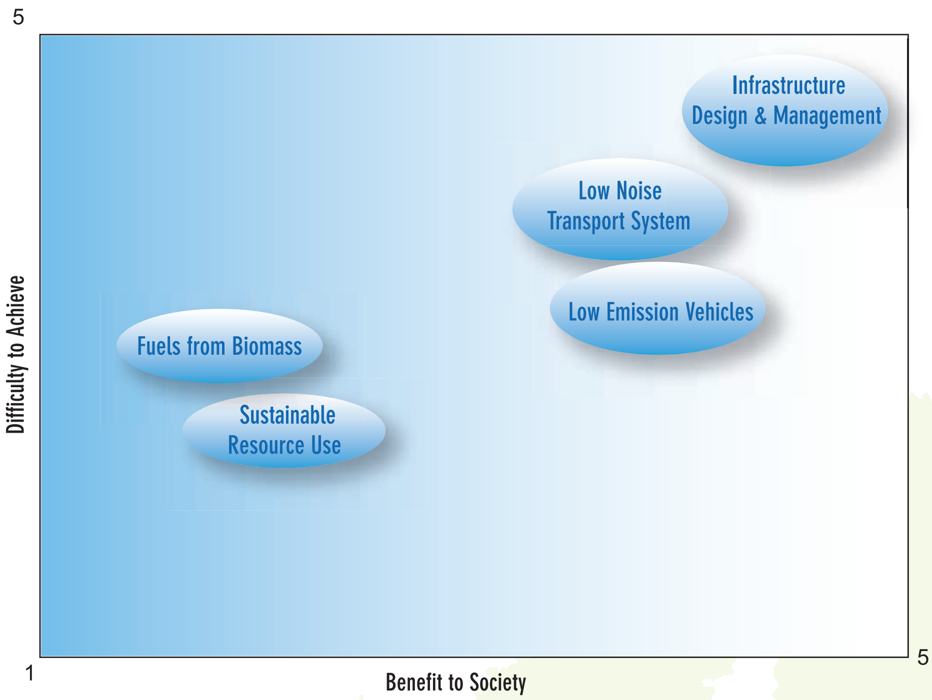
7• Environment-Including Impact on Communities and Natural Habitats

In some regions in Europe, the road network is so dense that the impact on the environment has reached the acceptable limits regarding noise and vibration, water quality, land use, visual pollution and natural habitats. Research is needed to reduce these undesired impacts of the road infrastructure on the environment. Emissions from road vehicles have reduced substantially, but further research is needed to achieve the target of near-zero emissions while also maintaining vehicle performance and reducing CO_2 emissions at lowest cost.

In order to reduce road traffic noise and vibrations to acceptable levels, for example as recommended by the World Health Organisation, an integrated approach is necessary, in which the interactions of vehicles, infrastructure, traffic and environment are considered. In particular the studies of tyre / road surface interactions should lead to better tyre design and to new low-noise road surfaces and pavement structures. Pavement maintenance techniques, in particular for the low noise porous surface layers should be improved.

In order to make the vehicle industry and the related recycling industry sustainable, a focus will have to be made on the topics of Design for Environment (DfE), material use and utilisation, recycling technologies and recycling infrastructure.

Low Emission Vehicles, meeting Euro 4, 5 and 6 and progressively introduced up to 2020 will dramatically reduce vehicle impacts on air pollution, while developing a **Low Noise Transport System** will require a systems approach. Research is needed on road **Infrastructure Design and Management** to mitigate its impact on people and natural habitats. Increased use of renewable materials and recycling will lead to **Sustainable Resource Use**, while the impact of **Biofuel** crops on water pollution and biodiversity also need to be considered.



7.1 Low Emission Vehicles

Vehicle Exhaust Emission Reduction

- Developments of ICEs noted under section 6.2 will contribute to maintaining low engine-out emissions.
- Exhaust after-treatment will remain important: Advanced catalyst materials, including nano-technologies offer the potential to deliver more effective catalyst performance.
- Emissions inventory models and road transport emissions forecasting tools need to be updated to understand the impact of implementation of new technologies.
- Further improvements in advanced emission control and aftertreatment are required including better performance under cold start and off-cycle conditions, affordability, increased durability, and reduced packaging.
- Advanced combustion systems will require effective and durable NOx control under lean conditions and control of particle formation while avoiding production of additional undesired emissions.

Other Vehicle Impacts

- Reduce non-exhaust emissions such as evaporative emissions, brake and tyre dust, and limit splash.

7.2 Low Noise Transport System

- Traffic noise and vibrations produced by vehicles should be prevented at the source, requiring research on :
  - Extensive shielding or even full encapsulation of powertrains with improved thermal control,
  - Parametric modelling of whole vehicle noise for all noise generation mechanisms and transmission paths and operating conditions,

- Highly damped materials for load carrying structure of engines, transmission and other vehicle components,
- Active noise control, e.g. intake and exhaust, or tyre noise,
- Intelligent management of engine transmissions for optimum quiet operation of vehicles.

▸ Existing traffic management systems need to be improved to smooth traffic and thus reduce noise and vibration.

▸ Improved noise measurement techniques should be investigated to more closely link measured noise to human perception and health. These elements need to be considered in conjunction with Infrastructure Design and Management outlined in section 7.3.

7.3 Infrastructure Design and Management

Road Engineering and Design

▸ The impact of road infrastructure needs to be considered from the design stage to reduce the visual impact of major roads, protect natural habitats and control water run-off, and effectively accommodate low speed and non-motorised transport.

▸ Consideration of life cycle assessment is needed for maintenance and construction materials and the use of ITS to smooth traffic flow.

▸ Further research on noise mitigation is needed including road screening that is effective and cost-efficient, reflective buildings, new design concepts and new noise absorbing materials.

▸ Methodologies for the assessment of land planning policies need to be developed, taking account of the visual impact of the road infrastructure and the consequences on the natural habitats.

▸ New infrastructure design concepts are needed for the preservation of natural habitats using road tunnels, green viaducts, ecological site selection and route design.

▸ More aesthetic solutions for infrastructures need to be found to reduce visual pollution. New design concepts using the space above and under the pavements need to be explored in order to limit the land take for roads.

Road Network Management

▸ Improve existing traffic management systems to smooth traffic and thus reduce noise and vibration production and transmission.

▸ Explore telematics solutions for better traffic management and smoother traffic flow to reduce emissions and noise, and contribute to more efficient road use. Low speed and non-motorised transport must also be accommodated.

Control of Water Quality

▸ Further study is needed on the impact of road transport on water quality using life cycle assessment to evaluate direct emissions from roads and vehicles, and indirect effects such as the production of biofuels.

▸ Impact on groundwater quality from splash, spray and surface run-off can be reduced through the following developments:

- Limiting splash and spray of surface water by vehicles, using porous pavements and developing methods for cleaning and prevention of clogging of such pavements,
- Reduction of non-exhaust emissions, including fine particulates from brakes, tyres, clutches, etc.,
- New options for intelligent spraying of de-icing solutions, preventive treatments or pavement heating systems,
- Capturing contaminated water and improving the drainage systems to control the release of any residual.

▸ Local water treatment methods should be developed for situations where no direct connection to sewers for wastewater is possible.

7.4 Sustainable Resource Use

Design for Environment and Recycling

▸ Ways to reduce waste from vehicle use should be investigated, including lube oil and other liquids, filters, catalysts, etc.

▸ Improved design tools are needed that directly incorporate consideration of environment, recycling and waste reduction. Design for Environment (DfE) and Design for Recycling (DfR) tools and methods require continuous evolution to achieve a holistic approach. Continuous adaptation of the tools to new materials and technologies is crucial for their acceptance and successful application.

▸ Design tools for integrated systems and the combination of various materials are needed to achieve recycling and cost targets.

Increased Use of Renewable Materials

▸ New material concepts, including composites that permit construction of lighter vehicles, are needed to fulfil both the recycling and the lightweight construction targets.

▸ The development of recyclates fulfilling technical, functional, and design specifications to the same extent as virgin materials is required to intensify the reuse of materials, especially polymers.

▸ The combined use of conventional and renewable materials should be studied further.

▸ Innovative, industrial scale recycling and separation technologies that provide material flows at adequate volumes and quality are a key requirement for economically viable processes.

▸ Efficiency improvements in dismantling processes are needed for high volume, cost effective operations.

▸ Issues related to the material shredder process remain to be solved such as post shredder material selection and the treatment of shredder light fraction (SLF).

▸ Reversible joining methods are needed to prevent the mixture of incompatible materials in the recycling phase and liberate pure material fractions as a valuable product for the material recycling market.

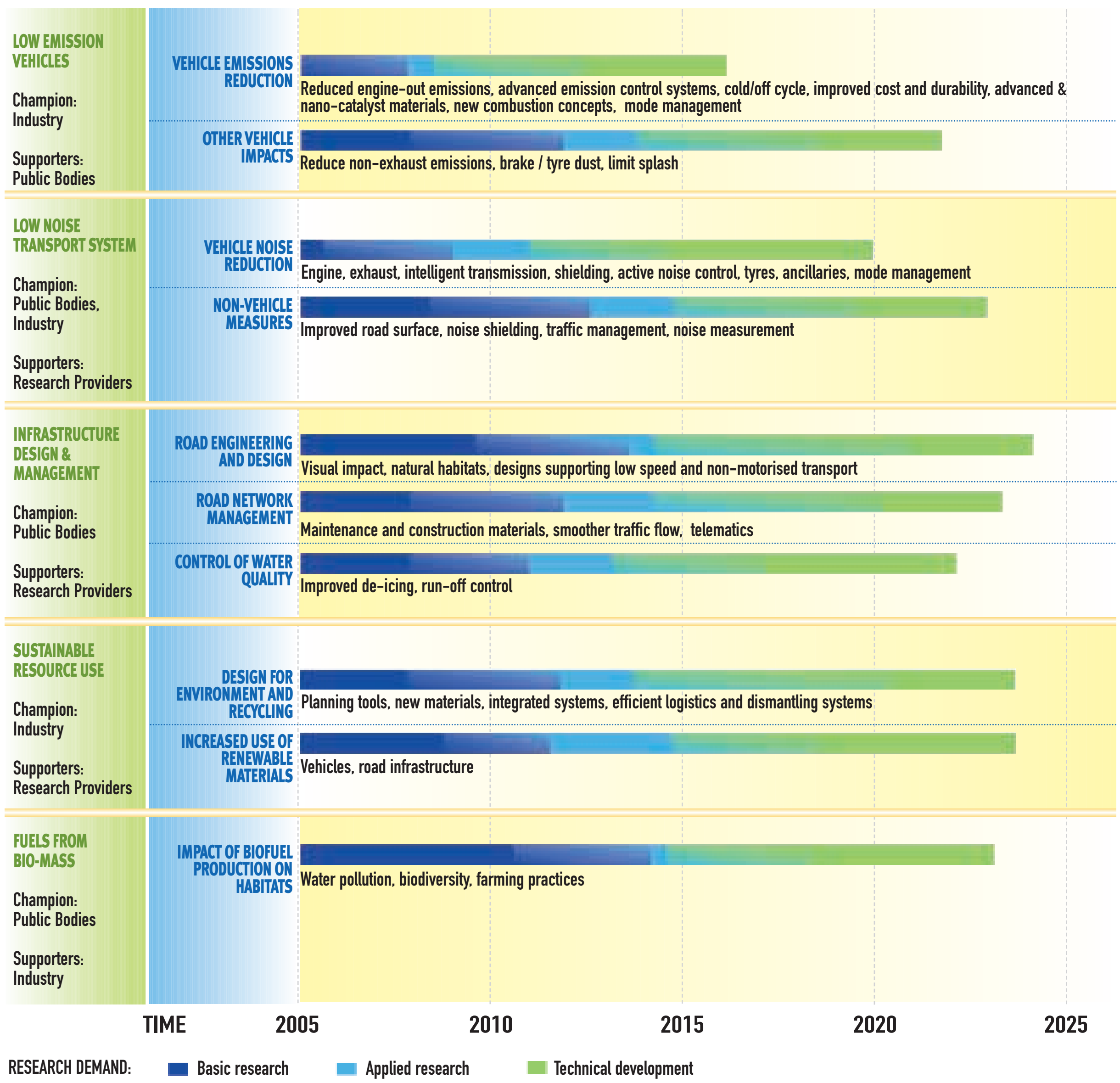
▸ Further improvements in road construction and demolition waste recycling technologies are needed to increase the percentages of recycled material that can be used in production of new high quality pavement surface layers.

▸ Highly efficient logistics concepts are needed to co-ordinate and optimise material flows from the EVL dismantler to component and material fractions specialists as logistics has a strong impact on the overall economics of the recycling business.

7.5 Fuels from Biomass

▸ The benefits of biofuels arise from energy substitution and GHG reduction. However, research is needed to understand the impacts of new crops and farming practices on rural economies, natural habitats, water and air pollution.

Environment – Including Impact on Communities and Natural Habitats



DESIGN & PRODUCTION SYSTEMS

Vision of highly competitive and sustainable systems for products and services

Whereas the first three pillars (Mobility, Transport & Infrastructure, Environment, Energy & Resources and Safety & Security) define what technologies should be addressed to improve sustainability and quality of life, the Design & Production Systems chapter addresses European competitiveness. Design & Production Systems requires a global approach to design, in parallel with enabling technologies and materials considering scope and timing.

MAJOR ASPECTS OF THE ERTRAC VISION 2020:

- Transport and infrastructures industries to a high degree use new management, production and design systems to satisfy the increased demand for sustainable mobility while at the same time maximising the benefits to society and increasing the choice available to end-users.
- Vehicles and infrastructure have increased quality and are more efficient over their lifetimes because they are developed with an integrated view of road infrastructure, components, materials and fuels.
- Vehicles and road infrastructure are designed to minimise their environmental impact. An accurate Life Cycle Analysis allows clean production and a high recycling rate. Recycling is an economic success.
- The system for supplying parts, manufacturing vehicles and delivering them to consumers causes minimum environmental damage while remaining flexible to respond to consumer needs, including time to market, price and reduced maintenance.
- The information systems of vehicles and roads are robust and open which means they can be updated or individualised as new features are developed.
- Enabling technologies such as lightweight materials, electronic systems, information and communication technologies and nano-technologies allow the industry to meet engineering goals at acceptable cost and strengthen its competitiveness.
- The transport infrastructure asset is managed through the use of performance models and optimisation tools.
- Innovative construction and strengthening techniques for bridges and other structures are established to support rapid construction, long life service ability, low maintenance costs and recyclability.
- Modularity for pavement allows parts of the pavement (e.g. surface courses) to be developed on short time scales without detriment to other, often longer-lasting parts of the pavement.
- The transport industry will have the right framework as to contribute to the Union's goal "... to become the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion."

DESIGN & PRODUCTION
Vision of highly competitive and sustainable systems for products and services
Expectations and Targets
Research Area Descriptions
8• Time to Market and Implementation
9• Flexible Production Systems
10• Lifetime Resource Use

Expectations and Targets

Future design and production has to be seen as an integrated system. The research objectives are generic but important criteria to effectively fulfil the functional research targets identified in the previous chapters. Competitive and sustainable design and production systems will ensure that European products are attractive to customers inside of the European Union and beyond.

Future design and production systems will allow customers to access a customised vehicle product that exactly meets individual requirements and society goals in terms of energy consumption, emissions, safety, security, noise, mobility and cost including servicing.

New customer-oriented production methods based on highly flexible, configurable and reliable production and delivery systems will enable customer order-to-delivery times for passenger vehicles of less than 5 days by 2020.

The application of robust, reliable and innovative manufacturing systems will allow 100% utilisation of production sites and enable achievement of world-class productivity. Innovative, clean, energy efficient factories will enable the marginalized, edge-of-town Industrial Estate to progressively give way to new, integrated Science-Technology-Manufacturing - and even Education - Parks situated in prime locations in terms of transport, communications, amenities and the environment.

Design and production systems are the platform to link road infrastructure, components and materials, vehicles and fuels in order to enable higher quality and lifetime efficiency. Safety, comfort and traffic management in particular will be increased or optimised through this enhanced systems approach.

Road infrastructure must be designed, constructed and maintained in a cost-efficient and sustainable way. It should also be well integrated in its environment contributing to its management in terms of noise and vibration absorption. Via simulation, monitoring and performance prediction, the lifetime of the infrastructure and its maintenance methods will be optimised.

Enabling Technologies

New road transport technologies such as light materials, electronic systems, and information and communication technologies (ICT) with specialised functions must be developed to meet the challenges of reduced vehicle weight, emissions, and noise levels and support improved individual mobility and freight transport – all at acceptable costs.

Virtual and networked companies linked through instant data-exchange can contribute to reducing future development costs of vehicle and infrastructure products and their components by 10-30%.

ICT and high performance manufacturing methods can increase the speed and flexibility of process flows. Directly linking each member of the supply chain could dramatically reduce waste and increase performance.

Electronic Systems and Information and Communication Technologies (ICT)

Electronics and communication systems are important technologies for driver assistance systems, enhancing safety of all road users and improving the security of goods. They also provide infrastructure support for incident and efficiency management, for on-board services and info-mobility applications.

Novel systems for mobility and transport are possible through e-safety, e-security, e-payment, e-emissions control, and e-navigation technology developments.

Environment

Concerns about the environmental impacts of material and product manufacturing and end of life disposal have led to calls for achieving targets for reuse and recycling of 98% for infrastructure and 95% by average weight per vehicle.
The introduction of clean maintenance (disassembly / assembly) management goes side-by-side with advanced reuse strategies.

Engineering Materials

According to international estimates, the majority of product and process innovations will be based on improved or newly developed materials in the next one to two decades. New materials are therefore regarded as particularly important for future technology development worldwide. Advanced materials will enable the production of smaller, smarter, multi-functional, and more easily customised components and products. The capability to accurately model the behaviour of new materials and their related production processes is vital for successful evolution and revolution of vehicles and road transport infrastructure.

Assets Management

Resources for new infrastructure investments will remain limited. The cost of both initial investments and maintenance will likely increase especially for urban transport systems. New forms of cooperation between private and public parties are needed.
To minimize the life cycle cost for the road infrastructure, methods and tools for asset management must be developed to optimise the financial planning of both the entire infrastructure system and specific sections.

The specific Research Targets are:

- Cycle times from new product concept to market will be reduced by at least 50% from today's best practice standards.
- Evolution of virtual tools will reduce future development costs of vehicle and infrastructure products and their components by 10-30%.
- Flexible production and delivery systems will enable order-to-delivery times for passenger vehicles of less than 5 days by 2020.
- World-class productivity will be achieved.
- The application of robust, reliable and innovative manufacturing systems will allow 100% utilisation of production sites.
- Continuous production of road surfaces will become possible throughout the full spectrum of climatic and operating conditions.
- New solutions will enable reuse and recovery of materials of 98% for infrastructure and 95% by average weight per vehicle.

Research Area Descriptions

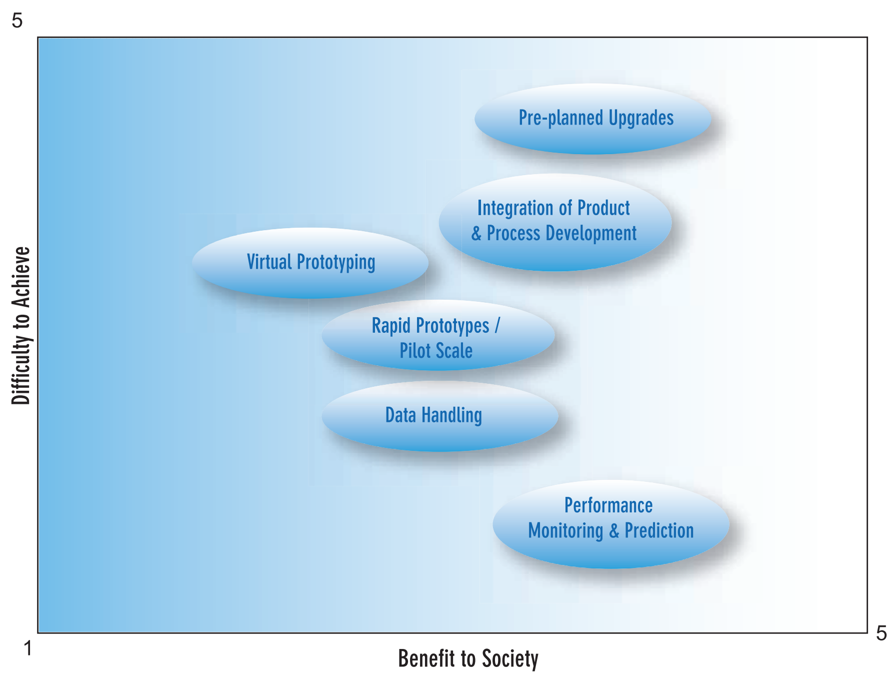
The research themes associated with the Design and Production chapter have been organised around three central themes:

8• Time to Market / Implementation
9• Flexible Production Systems
10• Lifetime Resource Use

The research areas in this chapter are often the basis or necessary enablers for successful development and implementation of research objectives outlined in the preceding chapters. The need for a broad range of sophisticated modelling and IT tools, advanced materials, and new processes are addressed with their related subjects.

8• Time to Market / Implementation

Faster time to market and quicker implementation of new processes and technologies depends on advances in **Data Handling** systems. **Virtual Prototyping** can accelerate the decision making process and reduce costs of physical prototyping. Increased flexibility can be gained from **Rapid Prototyping and Pilot Scale** production methods. Increased cooperation between stakeholders and shorter lead times are possible with new tools for Integrated **Product and Process Development**. To reduce long term investment costs and ensure new technologies can be brought to market quickly new methodologies and tools are needed for **Pre-planned Upgrades**. Scenario forecasting methodologies and testing methods for **Performance Monitoring and Prediction** can be applied to processes, vehicles and infrastructures to ensure quality and productivity and reduce cost and downtime.



8.1 Data Handling

In addition to more efficient design, simulation and production systems, open and shared data repositories, regularly updated and available throughout Europe, will help to assess different scenarios in terms of time-to-market, cost efficiency and environmental friendliness.

Open and Shared Data Repositories

- Open and shared data repositories to improve the cooperative working and simultaneous engineering processes between the various stakeholders of the vehicle manufacturing and road construction domains are required for provision of harmonised, integrated knowledge.
- Develop systems for knowledge management of road infrastructure, including pavement composition and structure, maintenance history, road equipment, and utilities placed in or under the pavements, in order to provide better input for design modifications and infrastructure upgrades.
- The creation and implementation of shared databases must address concerns related to information security and intellectual property protection.

Data Generation, Processing and Visualisation Technologies

- Data generation, processing and visualisation technologies will contribute to advanced virtual modelling and simulation capabilities as well as more effective decision-making tools throughout the supply chain.
- ICT linked and co-ordinated production and supply network should be connected to real-time seamless production webs and information flows.

8.2 Performance Monitoring and Prediction

Scenario forecasting methodologies and testing methods based on simulation and modelling technologies are key to predict the product performance and accurately monitor the behaviour of systems, components and materials. Vehicles, roads and infrastructures will heavily rely on sensor based electronic systems for in-service prevention and monitoring in production, construction or maintenance.

Sensor Based Electronic Systems

- Embedded systems require cost-effective solutions through hardware and software developments. Research is needed on open architectures and new sensor technologies to achieve improvements in optimisation, cost reduction, safety, security, reactivity and reliability.
- Research is needed for cost-effective, high volume, sophisticated production technologies for electronic components, including smart sensors and actuators to enhance reliability, durability and reconfigurability of numerous vehicle functions such as:
  - Technologies to provide “enhanced vision” e.g. radar applications based on microwave technologies, infra-red or laser,
  - X-by-Wire control systems to improve vehicle dynamics,
  - Information provision regarding road status and identification of vehicle surroundings,
  - On-board computing and sensor integration,
  - New systems for fuel injectors, accelerometers, pressure and flow sensors, mechanical filters and micro-electromechanical systems.

Performance Monitoring and Prediction

- Technologies are needed to convert information into knowledge for improved diagnostics and effective decision making.

▸ Comprehensive, flexible and cooperative real-time simulation techniques should be developed and applied throughout the supply chain addressing issues of cost, resource, time to market, production, customisation, disassembly and servicing.
▸ Reliable methods and tools to predict material, component, or vehicle behaviour and performance are necessary for effective life cycle management.
▸ Simulation models for architecture, modules and platforms for transport systems should be elaborated.
▸ For performance monitoring and prediction of road pavement wear, studies on vehicle-pavement interaction and in particular tyre-pavement interaction are required.
▸ To improve the quality of infrastructure construction and maintenance, traffic-friendly monitoring and high-speed quality inspection capability should be developed.
▸ Automatic guidance and robotisation of construction equipment, using new and precise positioning systems and automatic steering, would also contribute to higher quality, productivity and worker safety.
▸ Innovative, high speed diagnostic testing for monitoring road conditions are required for assessing evenness, skid resistance, deflection, and surface deterioration. New sensor applications should be developed to provide improved and / or self-diagnostic assessment for more effective maintenance and minimised traffic disturbance.

Forecasting Scenario Methodologies

▸ Simulation methods and models for forecasting the impacts of environment-related technology decisions and policy actions are a prerequisite for life cycle assessment of the road transport system.
▸ Develop knowledge management systems for sites and data handling systems for planning, design, construction and maintenance of road pavements and structures including better methods for localisation and recording information on underground public utilities.
▸ Functional requirements for road pavements need to be studied in order to allow for new types of construction and maintenance. This requires further development of performance monitoring methods for road pavements and structures and modelling of their behaviour over time.

8.3 Virtual Prototyping

At the crossroads of rapid prototyping and data handling, prototyping will benefit from both the ICT-based virtual world and the increasing modularisation and standardisation.

Digital Techniques and Virtual Reality

▸ Extend digital techniques and virtual reality applied to manufacturing such as the “virtual factory” to the prototyping and visualisation of new product concepts.
▸ To reduce cycle times and improve product performance through pre-validation, technologies for high quality virtual prototyping are needed which can be shared between customers and suppliers.
▸ Tools for stochastic and self-learning simulation and immersive virtual reality would lead to advances in the validation of concepts and products and the ability to evaluate and select solutions.

Comprehensive Decision-making Systems and Tools

▸ Flexible tools for seamless flow and integration of data between products and processes are needed for faster implementation and time to market.
▸ Product and process development would benefit from advances in self-learning simulation tools.

8.4 Rapid Prototypes and Pilot Scale

Based on robust design and predictive engineering tools and high performance manufacturing, highly flexible and configurable production systems will allow faster production of small batches including pilot scales and prototypes.

ICT based product and process design efficiency in parallel to modularisation and new standards will lead to greater electric components and systems availability, whereas pavement and infrastructure sub-systems will be developed on shorter time scales.

Advanced Rapid Tooling and Prototyping Technologies

- Robust design and predictive engineering tools are needed for efficient but flexible production with more options for individualisation, reconfiguration and upgradeability.
- Advanced rapid tooling and prototyping technologies, such as die-less forming, are desired for mechanical and electronic/electric vehicle components and systems.

Flexible / Autonomous / Configurable Production Systems

- Highly flexible, autonomous and configurable production systems, such as modular machines, assembly lines and facilities must be further developed and implemented. This should allow variable assembly and small batch production of specialised materials, components and systems, and vehicle and infrastructure modules at reasonable costs for customised orders, niche applications and markets, and small series.
- Advanced materials associated with new processes are needed for application on faster or shorter applications or final assembly:
    - Finished or semi-finished light weight materials,
    - Structural material systems incorporating innovative polymers and reinforcements,
    - Mixtures between metals, organic, and mineral based materials on a micro-structure level.

Pilot Scale Assessment Tools

- Pilot scale assessment tools for road construction and prototypes of infrastructure subsystems must be further developed to eliminate scale effect and allow accelerated testing.

8.5 Integration of Product and Process Development

Vehicles and road infrastructure will be developed in shorter lead times while increasing their quality, cost effectiveness and lifetime performance, through strong cooperation between developers of systems, components, materials and fuels. The availability of modular components integrated in open and model driven architectures and pre-processed materials will lead to longer lifetime and easier construction and maintenance methods as well as to more easily customised products.

Tools for Cooperation and Context Consideration

- Develop methodologies and models to integrate the networks between the material flow (the Physical Factory) and the information flow (the Virtual Factory). These should be flexible and adaptive to changing demands.
- Comprehensive, flexible and cooperative tools are needed for effective systems approach to design and development between fuel providers, vehicle manufacturers and suppliers, and infrastructure and service providers. ICT tools should support research of new systems solutions and their evaluation and selection for implementation.
- Appropriate interfaces should be investigated and defined for cooperative design, testing and development among the different actors. This includes workstation functionality definition.
- New design tools should adopt new approaches from artificial intelligence and virtual reality research.
- New forms of cooperation agreements should be developed and evaluated for use in new public-private partnerships with the intention of fostering innovation.
- Tools for the conceptualisation and design of multimodal networks and exchanges for local, regional, national and international levels must be advanced further.
- "Green" design tools and methods are required for integrating conceptual design, manufacturing, assembly, reuse and cost / benefit analysis for safer and more sustainable vehicles and infrastructures. New design concepts should ensure rapid uptake of new safety and environmental features.

▸ Decision methodologies incorporating economical, ecological, technical and social aspects should be defined for application to new concepts, materials and processes.
▸ Innovative tools and methods are required for road infrastructure planning and design in order to reach targets for product and process sustainability, durability and safety, and a better environmental integration. This should also include consideration of asset management to optimise the investment and maintenance for both the entire infrastructure system and individual sections.

Concurrent Engineering
▸ Simulation and validation of product design, material selection, and production processes of all types is necessary to speed implementation and avoid unnecessary costs or delays.
▸ Integrated data handling and virtual reality usage, from customers to suppliers, should be implemented to incorporate new knowledge, improve simultaneous engineering and achieve shorter cycle times.
▸ Tools for concurrent engineering are requisite for achieving faster time to market and world class level of competitiveness. These should support the systems approach to design and development between fuel providers, vehicle manufacturers and suppliers, and infrastructure and service providers.
▸ Open architectures should continue to be developed and applied to electronics for vehicles and their systems, sub-systems and modules including the powertrain, enabling greater choice in functionality for vehicle makers, suppliers, and customers. The need for open architectures applies also to ITS technologies for road transport infrastructure and services.

Modular Components and Pre-processed Materials
▸ New modular design and construction concepts are needed for vehicle body, powertrain and electronic systems for increased flexibility and faster upgrades. Module design should address the ease of assembling sub-systems.
▸ Modular systems and assembly / disassembly technologies should be explored to support vehicle and infrastructure recycling targets and the associated economic feasibility at reasonable costs.
▸ New design concepts are necessary for modular, factory-constructed pavements and structures. Such new concepts should include new materials and allow for the separation of the functions of different pavement layers.
▸ Requirements for faster and / or shorter manufacturing processes include:
- Light weight finished or semi-finished materials,
- Improved dispersion properties for colour and catalytic coatings,
- Optimised bonding processes.

▸ Advanced road materials are required such as:
- "Soft" materials for curbing and traffic routing to reduce concrete coring and breakage,
- Self-cleaning and regenerating materials,
- Fluids for infrastructures maintenance at low cost,
- Reduced frequency and cost of maintenance and increased quality during production under variable weather conditions.

8.6 Pre-planned Upgrades

Standardisation of information technologies applied to open architectures, both functional and physical, will offer more design and updating options in the design of the vehicles and the transportation infrastructures throughout their lifetime.
Knowledge management, data handling systems and modularisation in parallel to new standards will lead to seamless upgrading processes, reduced lead time as well as to increased and more uniform performance for vehicle manufacturing or road construction.

Standardisation of Information Technologies

- Robust and open information systems for vehicles and roads must be developed to allow updating and customisation as new features become available.

Modularisation in Parallel to New Standards

- Modularity for road infrastructure including ITS, is required for more rapid implementation without detriment to other, often longer-lasting parts.
- Integrated, prefabricated systems are needed for reduction of road traffic noise and air pollution with passive and active control functions.

Seamless Upgrading Processes and Reduced Lead Time

- Knowledge management and data handling systems based on modular concepts should lead to seamless upgrading processes and more efficient planning, design and production of vehicles and vehicle systems and construction of road surfaces and structures.
- Comprehensive, flexible and cooperative real-time simulation techniques should be applied to electronic systems such as vehicle "plug and play" and ITS components.
- To improve road infrastructure construction, upgrades and maintenance efficiency, new design concepts for modular, factory-constructed pavements, modular bridges, and replaceable elements, specially joints and bearings are required. These should include improvements in construction and maintenance methods and longer lifetimes.

Time to Market / Implementation

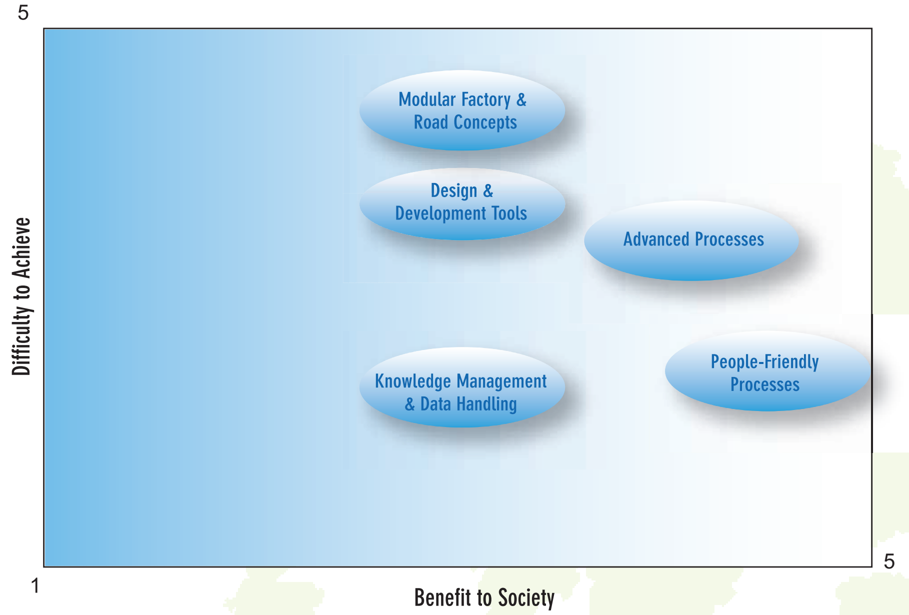
DATA HANDLING Champion: Industry Supporters: Public Bodies	OPEN AND SHARED DATA REPOSITORIES	Regularly updated and available within coordinated networks
	DATA GENERATION, PROCESSING, AND VISUALISATION TECHNOLOGIES	ICT linked and coordinated production and supply network
PERFORMANCE MONITORING & PREDICTION Champion: Industry Supporters: Research Providers, Public Bodies	SENSOR BASED ELECTRONIC SYSTEMS	Open architecture and new sensor technologies
	IMPROVED RECORDING & MONITORING	In service monitoring for production, construction and maintenance
	FORECASTING SCENARIO METHODOLOGIES	Cost modelling, testing methods
VIRTUAL PROTOTYPING Champion: Industry Supporters: Research Providers	DIGITAL TECHNIQUES AND VIRTUAL REALITY	Extension from manufacturing to design and development application
	COMPREHENSIVE DECISION MAKING SYSTEMS AND TOOLS	Seamless integration of products and processes
RAPID PROTOTYPES / PILOT SCALE Champion: Industry Supporters: Research Providers	ADVANCED RAPID TOOLING AND PROTOTYPING TECHNOLOGIES	Applications for mechanical and electric/electronic car components ans systems
	FLEXIBLE / AUTONOMOUS / CONFIGURABLE PRODUCTION SYSTEMS	Variable assembly systems
	PILOT SCALE ASSESSMENT TOOLS	Reduced scale effect of infrastructure subsystem prototypes
INTEGRATION OF PRODUCT AND PROCESS DEVELOPMENT Champion: Industry Supporters: Research Providers	TOOLS FOR COOPERATION AND CONTEXT CONSIDERATION	Systems approach for component, material and fuel stakeholders
	ARTIFICIAL INTELLIGENCE & VIRTUAL REALITY / CONCURRENT ENGINEERING	Real-time and ICT linked networks
	MODULAR COMPONENTS AND PREPROCESSED MATERIALS	Application for systems, vehicles and infrastructure elements
PRE-PLANNED UPGRADES Champion: Industry Supporters: Public Bodies	STANDARDISATION OF INFORMATION TECHNOLOGIES	Open architecture both software and hardware
	MODULARISATION IN PARALLEL TO NEW STANDARDS	Roads, bridges, tunnels, road - side infrastructure including ITS
	SEAMLESS UPGRADING PROCESSES AND REDUCED LEAD TIME	Vehicle manufacturing, infrastructure construction

TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research Applied research Technical development

9• Flexible Production Systems

In order to shorten cycle times and increase the level of customisation possible new **Design and Development Tools** are required. These must support flexible **Modular Factory and Road Concepts**. In order to achieve the required efficiency, new **Knowledge Management and Data Handling** concepts must be realised. New concepts and new materials demand that **Advanced Processes** are implemented which are both **People Friendly** and environmentally appropriate.



9.1 Modular Factory and Road Concepts

Easy maintenance, upgradeability and recovery of materials, components and equipment must be considered part of lean, flexible and modular manufacturing. Modular concepts for infrastructure will allow flexibility and shorter time scales.

Adaptable and Integrated Processes and Systems

- Adaptable, integrated processes including machines and assembly lines must become readily reconfigurable in conjunction with new modular and multi-functional units.

Configurable Machines and Assembly Lines

- Machines and assembly lines require increased capability for configurability including part and process monitoring and joining and assembling technologies.
- ICT links are needed for production and supply networks.

Modular Concepts for Infrastructure Construction

- New design concepts for infrastructure construction must be supported by modular manufacturing of multi-function structures and factory-constructed pavements and bridges.

9.2 Design and Development Tools

In addition to time-to-market objectives, design and engineering tools will have to cope with lean manufacturing and increased flexibility.

Virtual Reality and Factory

- The design and monitoring of factories should become virtual in order to plan and test changes and evaluate maintenance.

Closed Loop Simulation

- Comprehensive, flexible and cooperative real-time simulation techniques are required for closed loop planning of the entire production process from suppliers to vehicle manufacturers to support "build to order".

Comprehensive Simulation of Production Process Loop

- Simulation tools covering the entire production chain are needed for vehicles and components, fuels and infrastructure. This includes material supply, component and process modification, real-time process optimisation, verification and delivery.

9.3 People-Friendly Processes

In a fast changing environment with increasing competitive pressures, the development and production processes will require changes in the work force. This will make it necessary to better understand the impact of the work organisation on the human behaviour, in terms of health and safety, and enhance the human-machine interfaces, in R&D centres, factories as well as in open spaces like for road infrastructure construction or maintenance.

Human resource management and training will be keys.

Reliable, Integrated Machinery

- User friendly and highly reliable production systems must be developed for high standards of health and safety.
- Traffic-friendly monitoring is needed for road construction activities.
- New infrastructure elements with multi-function capability should mitigate environmental impacts and facilitate relationships between users, administration, utility companies and toll operators.
- New road maintenance management and rapid maintenance techniques are needed such as quick repair and renewal techniques, road elements designed for easier maintenance, and increased quality of night work.

Green Manufacturing Technologies

- Production systems must be modified and designed for low environmental impact: water and energy consumption, low emissions and noise levels, VOC / solvent free production, low temperature processing.

Workplace Ergonomics

- Overall workplace design and enhanced human-machine interface levels must contribute to a better image of the industry and to a sustainable production.
- Intelligent procedures incorporating physical and cognitive ergonomics are needed to develop sustainable production processes including safety and environmental monitoring.

Human Resource Management and Training

- New emphasis is required for a comprehensive approach to skills upgrading and competence enhancement of the work force.

9.4 Advanced Processes

Increasing modularisation and reduced system resource use will lead to a greater need for standardisation and for innovative automated joining technologies.

Processes will have to be suited to increased flexibility and variety in production batches. This includes adaptations for changing climate conditions and traffic-friendly management in the road construction industry.

Flexible, Configurable, Robust and Reliable Production

- Highly flexible and configurable production systems are required for variable assembly or the production of module based vehicles at reasonable costs in small volumes. New solutions must be investigated for robust and reliable production systems that are 100% production capable.
- Intelligent measurement, diagnostic and monitoring systems (on-line, continuous and real-time) are necessary for environmental and quality control, productivity, and sustainable production process tracking.

Automated and Adaptive Processes

- Advanced automated process technologies are needed for part and process monitoring and assembling / joining technologies. These new processes must be adaptive to new techniques and new materials.

Traffic-friendly Construction and Maintenance Techniques

- On site, flexible processes, materials and equipment are needed which can continually produce high quality products under variable climate conditions. Automated guidance and robotisation utilising precise positioning systems and automatic steering would improve quality including the accuracy of layer thickness and evenness.
- High-speed techniques for quality inspection are needed during road construction and maintenance for more traffic-friendly management.
- Construction techniques and standards (for example stabilisation and chemical improvement) are needed to improve performance with regard to road sub-grades and sub-base layers.

9.5 Knowledge Management and Data Handling

To support more efficient design, simulation and production systems, open and shared data repositories must be applied to vehicle and fuel production and infrastructure construction. These must aid in the assessment of different scenarios for flexibility, cost, efficiency, quality and environmental impact.

Open and Shared Data Repositories

- Open and shared data repositories feeding ICT systems for coordinated production and supply networks must allow access to real-time information and provide harmonised knowledge to all actors in the supply chain.

Data Generation and Digital Technologies

- Digital techniques must be developed and applied for instant data generation and processing inside virtual and networked companies to support decision-making.
- Data handling and sharing, combined with virtual reality usage, will improve the cooperative working and simultaneous engineering processes from customers to suppliers. This integration of knowledge would support production systems such as build-to-order.

Knowledge Based Production and Supply Networks

- Site knowledge management, data handling systems and ICT technologies are prerequisites for advanced processes for construction and maintenance of road and structures. These new knowledge management systems should enable automated guidance and pre-processing for construction and better methods for the localisation and recording of information on underground public utilities.

Flexible Production Systems

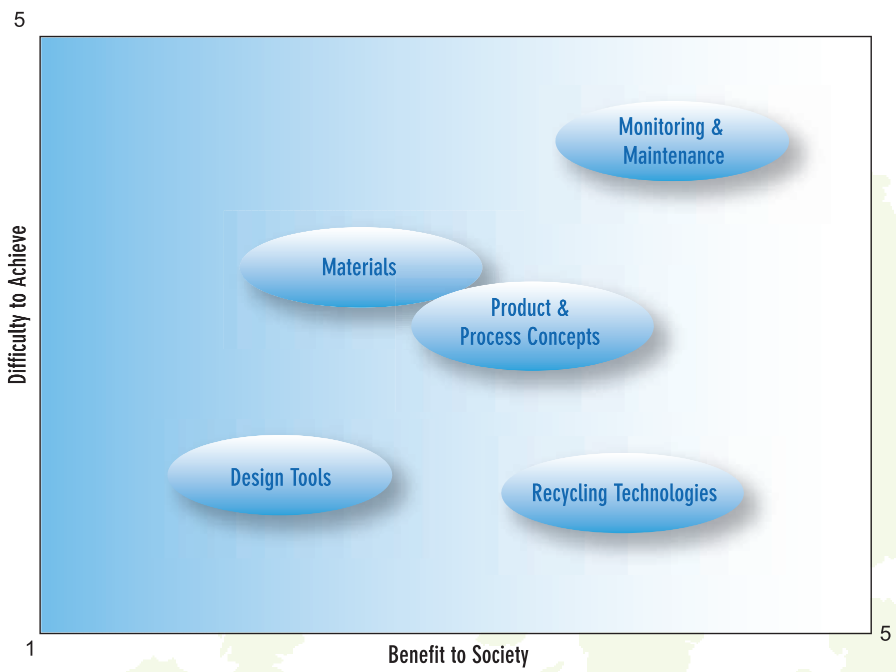
MODULAR FACTORY & ROAD CONCEPTS Champion: Industry Supporters: Research Providers	ADAPTABLE AND INTEGRATED PROCESSES AND SYSTEMS	Multi-functional manufacturing units
	CONFIGURABLE MACHINES AND ASSEMBLY LINES	Part and process monitoring, joining technologies
	MODULAR CONCEPTS FOR INFRASTRUCTURE CONSTRUCTION	Multi-function structures, factory-constructed pavements and bridges
DESIGN & DEVELOPMENT TOOLS Champion: Industry Supporters: Research Providers	VIRTUAL REALITY AND FACTORY	Design and planning tools, maintenance evaluation
	CLOSED LOOP SIMULATION	Entire production process at car manufacturers and suppliers
	COMPREHENSIVE SIMULATION OF PRODUCTION PROCESS LOOP	Life cycle from supply chain to OEM to recyclers
PEOPLE- FRIENDLY PROCESSES Champion: Industry Supporters: Research Providers	RELIABLE INTEGRATED MACHINERY	User- and traffic-friendly, new road maintenance technology
	GREEN MANUFACTURING TECHNOLOGIES	Low environmental impact
	WORKPLACE ERGONOMICS	Enhanced human-machine interface and safety
	HUMAN RESOURCE MANAGEMENT AND TRAINING	Skills upgrading, competence enhancement
ADVANCED PROCESSES Champion: Industry Supporters: Research Providers	FLEXIBLE, CONFIGURABLE, ROBUST AND RELIABLE PRODUCTION	100% production availability, high standards
	AUTOMATED AND ADAPTIVE PROCESSES	New techniques, new materials
	TRAFFIC-FRIENDLY CONSTRUCTION AND MAINTENANCE TECHNIQUES	High-speed quality inspection, automatic steering
KNOWLEDGE MANAGEMENT & DATA HANDLING Champion: Industry Supporters: Public Bodies	OPEN & SHARED DATA REPOSITORIES	Coordination of networks, services and systems, harmonised knowledge provision, European-wide access
	DATA GENERATION AND VISUALISATION TECHNOLOGIES	Virtual modelling and simulation with real-time database integration
	KNOWLEDGE BASED PRODUCTION AND SUPPLY NETWORKS	Control, decision support, data mining, statistics

TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research, Applied research, Technical development

10• Lifetime Resource and Use

The sustainability and competitiveness of the European road transport sector depend heavily on the development of new **Materials** and comprehensive **Design Tools** optimising processes over the entire chain and products over their entire lifetime. This requires new **Concepts for Products and Processes** including **Recycling Technologies** for both vehicles and infrastructure. High levels of performance across the system require new methodologies and technologies for **Monitoring and Maintenance**.



10.1 Design Tools

The prediction of environmental impact as well as long-term behaviour of materials, components and systems will benefit from decision-making tools. Tools for eco-design and continuous costs/benefits analysis are necessary for many applications such as enabling the economic achievement of recycling targets. Life cycle analysis of the complete road transport is essential to make the best possible technical and policy choices for increased sustainability of the system.

Decision-making Tools for Environment and Security

- Develop reliable methods and design, engineering and testing models to predict material, component or vehicle behaviour and performance over their entire lives.
- Innovative "green" design tools integrating conceptual design, production, assembly and reuse are required for economic achievement of safer and more sustainable vehicle, fuel and infrastructure systems.
- Simulation methods and models to forecast the environmental impacts of technology decisions and policy actions are needed.
- The relationship between materials and the success of a comprehensive recycling network should be studied.
- Creation of databases of sustainable development indicators would enable continuous environmental monitoring including remote censoring and geographic information system (GIS).
- Critical path analysis should be developed for holistic infrastructure scenarios to optimise decision-making.
- Design and simulation tools are needed to better protect road pavements, embankments and bridges against natural hazards such as floods, landslides and earthquakes, and impacts which may result from

climate change. Studies are also needed on vehicle-pavement interaction, in particular tyre-pavement interaction.

Global Road Transport Life Cycle Analysis (LCA)

- Fundamental material and energy studies are required to determine the stability of supply, life – cycle costs, – and social and environmental impacts for improving the sustainability of the mobility and transport system.
- Innovative tools and methods must be created to address road infrastructure “design for environment” in order to reach product and process sustainability, durability and safety targets, and better landscape integration. Further improvement need to integrate technology systems with energy recovery and cost effective performance.
- A holistic model of the logistics system is needed to evaluate its influences on the environment, both positive and negative.

10.2 Product and Process Concepts

Vehicles and road infrastructure will rely on modular and platform concepts to achieve performance for a sustainable transport system. Product and processes must be treated as an integrated system. In the following section is a list of components and systems that need innovative production solutions for a multi-material and multi-technology approach. In both domains of activities, the production systems will be environmentally friendly for citizens and workers in terms of health, safety and consumption of natural resources.

Modules and Platforms

- Open architectures for both software and hardware are essential for offering more options in the design and upgrades of the vehicles and transport and information infrastructures throughout their lifetime.
- Modular platform concepts based on clear definitions of use should be developed for specific or variable performance criteria such as emissions, long range or urban use, multimodal exchange.
- New modular parts or systems that reduce assembly and disassembly time are required to realise high levels of flexibility.

Product Performance

- New concepts for clean intermodal urban goods delivery should be researched.
- New solutions are needed for weight reduction of vehicles in order to reduce vehicle CO_2 emissions while respecting and optimising the targets for safety, cost and recyclability.
- Embedded systems and electronic components should be further developed for optimisation, cost reduction, safety, security, reactivity and reliability through sensor integration, on-board computing and common architecture.
- Reliable electronics and mechatronics systems must be made available for x-by-wire control systems to enhance vehicle performance. These technologies could also address changes in the vehicle configuration such as tyre pressure, aerodynamics or engine mode to optimise environmental performance.
- Technologies to provide “enhanced vision” such as microwave, infrared, laser or high-speed digital processing should be further developed for higher reliability and reduced cost. Automated Vehicle

Guidance could follow including automated management of high volume operations (HMI workload), integrated decision aids, precise control of the vehicle, and hazard detection and prevention.

- Wireless and remote diagnostic technologies for vehicles and infrastructure should be explored.
- Improvements in on-board energy management are needed including options such as APUs, batteries, advanced control systems, etc.
- Design concepts and assembly technologies are needed that support the achievement of recycling and cost targets.
- Technologies and systems for achieving a high level of communication between the infrastructure, vehicle and consumer are needed. These should focus on improving safety and reducing road congestion. Efficient multimodal exchange areas could be supported by a universal wireless environment extending from a "personal area network" up through local - and wide-area networks to satellite - based global connectivity.

Infrastructure - Climate Change and Natural Hazards

- Road pavements, embankments and bridges must be designed or reinforced for better protection against natural hazards such as floods, landslides and earthquakes, and impacts which may result from climate change. Current design methods will have to be evaluated and updated considering such hazards.

Environmentally Friendly Production Systems

- Productions systems must be developed and implemented which have low environmental impact such as "near zero" waste, minimal water and energy consumption, low emissions and noise levels. This includes "green" manufacturing technologies for VOC/solvent free production or low temperature processing.

10.3 Materials

Due to their high impact on natural resources consumption and their indirect impact on energy consumption, materials will be considered carefully. Manufacturing processes must steadily improve while high performance materials must be developed and made available to provide vehicles and structures with significant improvement in safety and weight reduction.

High Performance Materials for Vehicles and Infrastructure

- Multifunctional materials must be developed that can "self-adapt" their range of properties depending on the requirements during application for example self-healing (abrasion or wear), variable strength, or micro-encapsulated materials.
- Nano-structured and self-assembling materials should be explored for the production of products with new functionalities due to their mechanical, optical, magnetic, electrical or chemical characteristics.
- New materials and components should be investigated that are active and reactive through the integration of sensors or actuators within high performance materials. Some examples: include functional integration of "active materials" inside matrix materials, touch sensitive plastics, biodegradable parts with "slow" surface and "fast" core.
- High performance materials with acceptable costs are required for multiple applications such as weight reduction and creep resistance. These include Mg alloys, cast inter-metallic, titanium and aluminium applications, metal matrix composites, polymer glazing, nano-structures and new materials such as reinforced polymers for pavements and structures.

▸ Mixtures between metals, organic, and mineral based materials on micro-structural level may offer new alternatives. Materials for improved dispersion properties for colour and catalytic coatings are needed as well as new optimised processes for bonding.
▸ "Soft" materials for curbing and traffic routing are needed to reduce concrete coring and breakage and provide new safety features.

Low Material Consumption Processes
▸ Processes for management of vehicles and infrastructure materials are required to meet the challenges of reuse and recyclability of materials including aging and reliability concerns.
▸ Net shape engineering and topologic/structural optimisation tools are needed for optimising use of engineered materials with advanced functional integration and reducing costs for advanced lightweight material processing.
▸ New processes should aim to overcome material limitations.
▸ Cost-efficient and innovative processes are necessary for nano, pico, smart, gradient, ferrous - non-ferrous, plastic, composites or foamed materials. These materials should provide high performance characteristics such as strength or temperature resistance, durability, heat absorption or resistance, crashworthiness.

10.4 Monitoring and Maintenance

Intelligent and high-speed measurement procedures will rely on advanced electronic systems to support vehicle, road and infrastructure production, maintenance and environmental monitoring. Rapid maintenance techniques should also avoid traffic capacity reductions and road closures.

Electronic Systems for Performance Monitoring
▸ Vehicle monitoring and travel time prediction should be developed for different modalities such as pre-trip and dynamic journey information, according to type, distance travelled, time, avoidance of congestion or pollution reduction.
▸ New systems for providing information on road status and identification of vehicle surroundings are needed.
▸ Telematics communication systems must be developed for real-time information transmission between the infrastructure, vehicles, and individuals for:

- Infrastructure monitoring, maintenance and operating activities,
- Suitable management and operative processes for emergencies,
- Improved safety and avoidance or reduction of congestion.

▸ On line, continuous and real-time intelligent measurements procedures are necessary for production process and environmental monitoring including quality control systems, safety and productivity.
▸ Automatic guidance and robotisation of construction equipment, using precise positioning systems and automatic steering, should be developed for better quality such as more accurate layer thickness and

evenness, and allowing faster road construction and maintenance. Traffic-friendly monitoring and high-speed quality inspection during road construction would improve the quality of the construction.

Rapid Maintenance Techniques for Vehicles and Infrastructure

- Maintenance operations could be improved through application of digital techniques like virtual factory and augmented reality. Systems and materials capable of self-diagnostics and repair should also be developed.
- Fast and low cost road infrastructure maintenance depends upon new materials, components and fluids. Examples include interchange ability and compatibility of components, self-cleaning and regenerating materials and fluids.
- New road construction and maintenance management and rapid construction and maintenance techniques must be developed and implemented to avoid capacity reduction, road closures and coordinate with public utility work.

10.5 Recycling Technologies

Integrated, affordable robotic and automated processes are required for easy assembly and disassembly of complex parts, components and modules.

Technologies to Recover and Reuse Recycled Materials

- Lean, cost-effective recycling processes are needed for clean, worker-oriented, flexible and energy-efficient recycling.

Separation Tools /Techniques for Multi-material Vehicles

- Separation tools, techniques and technologies to recover and reuse post-consumer recycled materials from complex parts and modules are needed in particular for polymers, mixed materials and the shredder fraction.
- Further studies for robotic and automated processes are necessary for economically viable materials identification and sorting. Attention should be focused on improving the quality of the material streams.

Lifetime Resource and Use

Area	Research topic	Research demand
DESIGN TOOLS Champion: Industry Supporters: Research Providers, Public Bodies	DECISION MAKING TOOLS FOR ENVIRONMENT AND SECURITY	Behaviour and impact prediction, durability, reliability, landscape integration, recycling
	GLOBAL ROAD TRANSPORTATION LCA	Emissions assessment, sustainable use of materials and energy
PRODUCT & PROCESS CONCEPTS Champion: Industry Supporters: Research Providers, Public Bodies	MODULES AND PLATFORMS	Applications for vehicle parts and systems, road infrastructures, joints
	PRODUCT PERFORMANCE	Reduced weight and emissions, improved vehicle quality, assembly technologies, vehicle/pavement interaction
	INFRASTRUCTURE - CLIMATE CHANGE AND NATURAL HAZARDS	Protection and resilience for road pavements, embankments and bridges
	ENVIRONMENTALLY FRIENDLY PRODUCTION SYSTEMS	Worker health and safety, water and energy consumption
MATERIALS Champion: Industry Supporters: Research Providers	HIGH PERFORMANCE MATERIALS FOR VEHICLES AND INFRASTRUCTURE	Ultra-light, composites, reinforced, joining technologies
	LOW MATERIALS CONSUMPTION PROCESSES	Net shape engineering, precise positioning systems, re-usable materials
MONITORING & MAINTENANCE Champion: Industry Supporters: Research Providers Public Bodies	ELECTRONIC SYSTEMS FOR PERFORMANCE MONITORING	Products and production processes, infrastructure prediction and maintenance
	RAPID MAINTENANCE TECHNIQUES FOR VEHICLES AND INFRASTRUCTURE	Avoid capacity reduction and road closures, using self-cleaning and regenerating materials
RECYCLING TECHNOLOGIES Champion: Industry Supporters: Research Providers	TECHNOLOGIES TO RECOVER AND REUSE RECYCLED MATERIALS	Clean, worker-oriented, flexible and energy efficient production and supply
	SEPARATION TOOLS/TECHNIQUES FOR MULTI-MATERIAL VEHICLES	Disassembly of complex modules and parts, affordable robotic and automated processes

TIME 2005 2010 2015 2020 2025

RESEARCH DEMAND: Basic research Applied research Technical development

CONCLUSION

The wide spectrum of new technologies that has been presented in this SRA promises many innovative solutions necessary for achieving the Vision 2020. It is an exciting and challenging research agenda which requires the talents and dedication of men and women in companies, universities and research centres all over Europe. It also requires a sustained investment from the research to the implementation phase from both the public and private sectors.

Although ERTRAC's focus is research, it is not possible to achieve the Vision and the implementation phase without considering the constraints and factors for ultimate success. If the research results are to be exploited fully, then it is necessary to mention some of the constraints and success factors that need to be considered in parallel by actors outside of the research arena.

A best-in-class workforce of scientists, engineers and technicians motivated by the challenges of interesting careers and opportunities for mobility is fundamental to successful research programs.

Due to its life cycle and the heavy investment required, significant changes to the road transport infrastructure are slow. Therefore, land use and transportation planning needs to be integrated at local, national and international levels irrespective of borders. Maintenance, renewal and new construction projects need to make the best use of developing, innovative technologies and best practices to offer greater levels of service while providing opportunities for future upgrades.

Consistent and implemented standards are needed throughout Europe for a wide range of issues, be they accident prevention and mitigation, design and production, maintenance, new fuels and powertrain technologies, data bases, communication technologies, etc.

The existing legal framework must be adapted to open doors to new public-private partnerships, new services and new technologies.

People and society will need to be open to new solutions to mobility issues. However, all of the new services and nearly all of the new technologies depend on customer acceptance. Affordability and appropriate design are crucial. Neither engineers nor policy makers should forget that it is ultimately the customer who determines the value of the service or technology.

Research is essential for finding and proposing new solutions for developing a sustainable road transport sector. Technology alone will not provide all of the answers. All of us, as individuals, as companies and as Public Bodies, must take responsibility for changing established practices and begin making new choices with a clear understanding of the implications of our choices.

The ERTRAC Vision for 2020 is achievable if we continue to work together for a competitive and sustainable road transport sector.

GLOSSARY OF TERMS

ADAS	Advanced Driver Assistance Systems
APU	Auxiliary Power Units
AVG	Automatic Vehicle Guidance
BTL	Biomass to Liquid
CAD	Computer-Aided Design
CAI	Controlled Auto-Ignition
CNG	Compressed Natural Gas
DfE	Design for Environment
DfR	Design for Recycling
EDR	Event Data Recorders
ELV	End-of-Life-Vehicle
ERTRAC	European Road Transport Research Advisory Council
FAME	Fatty Acid Methyl Esters
FCD	Floating Car Data
FT	Fisher-Tropsch
FURORE	Future Road Vehicle Research
GHG	Green House Gases
GIS	Geographic Information System
GM	Genetically Modified
GTL	Gas To Liquid
HCCI	Homogeneous Charge Compression Ignition
HD	Heavy Duty
HMI	Human–Machine-Interface
ICE	Internal Combustion Engine
ICT	Information and Communication Technologies
ITS	Intelligent Transport Systems
ITU	Inter-modal Transport Units
LCA	Life Cycle Analysis
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NG	Natural Gas
NOx	Nitrogen Oxides
NVH	Noise/Vibration/Harshness
OBD	On-Board Diagnostics
OBM	On-Board Measurement
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
ORMOCER	ORganic MOdified CEramics
PEM	Proton Exchange Membrane
RFID	Radio Frequency Identification Devises
SLF	Shredded Light Fraction
SOFC	Solid Oxide Fuel Cell
SRA	Strategic Research Agenda
TDS	Traffic Dialogue Systems
VOC	Volatile Organic Compounds

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ERTRAC MEMBERS AND WORK GROUP

Industry and Associations

Ivan HODAC
ACEA

Johann GRILL
AIT / FIA

Helmut LIST
AVL List GmbH / EARPA

Giuseppe ROVERA
Centro Ricerche Fiat / EUCAR

Lars HOLMQVIST
CLEPA

Jean-Pierre MEDEVIELLE
ECTRI

José PAPI
ERF

Daniel AUGELLO
ERTICO

Jörg BECKMANN
ETSC

Peter TJAN
EUROPIA

Govert SWEERE
FEHRL

Rudolf KUNZE
Ford Motor Company / EUCAR

Isabelle DUSSUTOUR
POLIS

Pierre BEUZIT
Renault / EUCAR

Klaus HARMS
Robert Bosch GmbH. / CLEPA

Bart VAN HOLK
Shell UK Ltd. / CONCAWE

Jean-Luc MATÉ
Siemens VDO Automotive / CLEPA

Michael ALGER
Vodafone

Lars-Göran ROSENGREN
Volvo Technology Corporation / EUCAR

European Commission

Alfonso GONZALEZ-FINAT
DG Energy and Transport (DG TREN/D)

Heinz HILBRECHT
DG Energy and Transport (DG TREN/E)

Paul WEISSENBERG
DG Enterprise (DG ENTR/F)

Jos DELBEKE
DG Environment (DG ENV/C)

Rosalie ZOBEL
DG Information Society (DG INFSO/C)

Pablo FERNANDEZ-RUIZ
DG Research (DG RTD/J)

Jack METTHEY
DG Research (DG RTD/H)

Academia

Zissis SAMARAS
Aristotle University of Thessaloniki

Mike McDONALD
University of Southampton

Annika STENSSON
KTH Stockholm

Johann LITZKA
Vienna University of Technology

National Governments

Andreas DORDA
Austria

Jan VAN DEN BOSSCHE
Belgium

Ilieva TZVETELINA
Bulgaria

Josef MIKULÌK
Czech Republic

Knud Erik ANDERSEN
Denmark

Jukka ISOTALO
Finland

Jean DERAMPE
France

Konrad BAUER
Germany

G.A. GIANNOPOULOS
Greece

Laszlo RUPPERT
Hungary

Hreinn HARALDSSON
Iceland

Antonio ERARIO
Italy

James CAFFREY
Ireland

Neomy SOFFER
Israel

Aldona JARASUNIENE
Lithuania

William HELMINGER
Luxembourg

Menno OLMAN
Netherlands

Kjell BJORVIG
Norway

Edward MENES
Poland

Tiago FARIAS
Portugal

Adrian ESANU
Romania

Antonio CANO
Spain

Hans INGVARSSON
Sweden

Matthew WHITE
United Kingdom

ERTRAC Work Group Members

Dr. Josef AFFENZELLER
AVL List GmbH / EARPA

Dr. Neville THOMPSON
CONCAWE

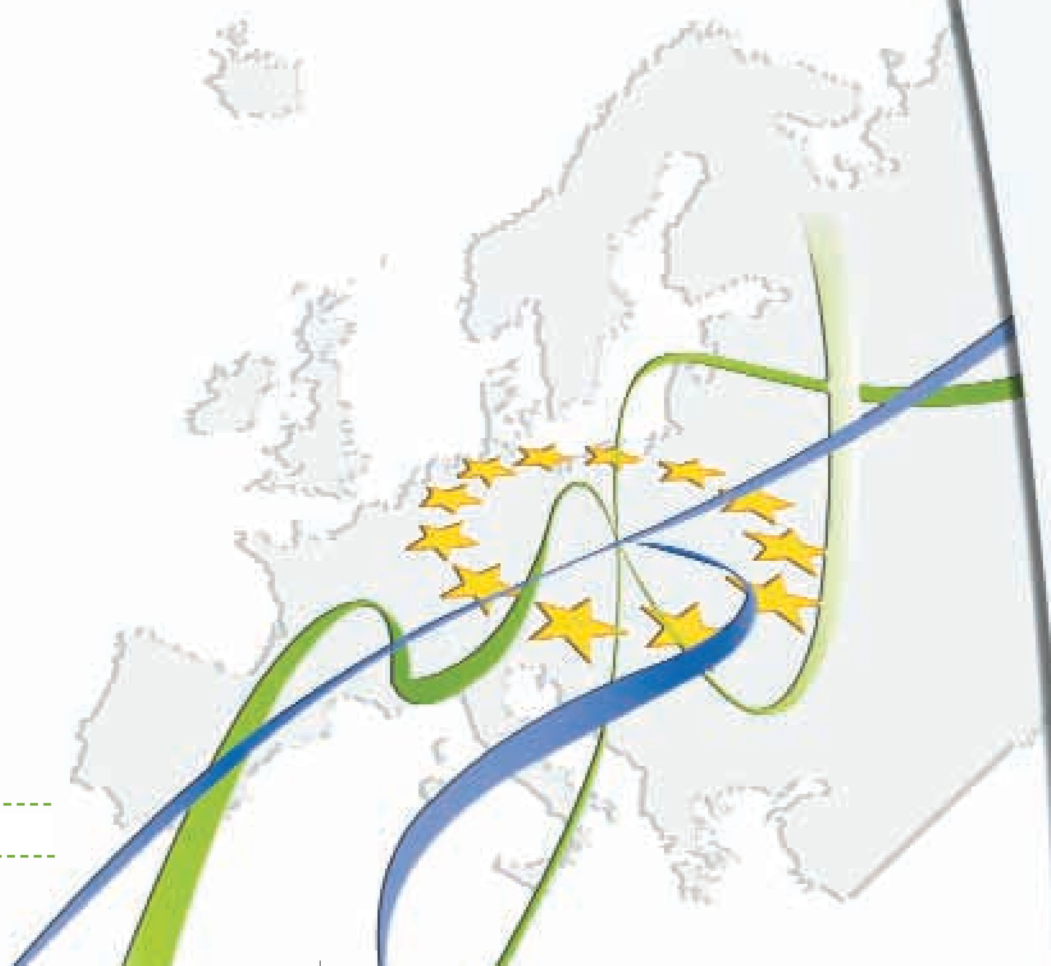
Dr. David RICKEARD
ExxonMobil / CONCAWE

Claude WOZNIAK
Faurecia / CLEPA

Steve PHILLIPS
FEHRL

Dr. Heinz HASS
Ford / EUCAR

Kimberley LANSFORD
Renault / EUCAR



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