European Road Transport Research Advisory Council

ERTRAC Research Framework

'Steps to Implementation'

March2008

CONTENT

EXECUTIVE SUMMARY

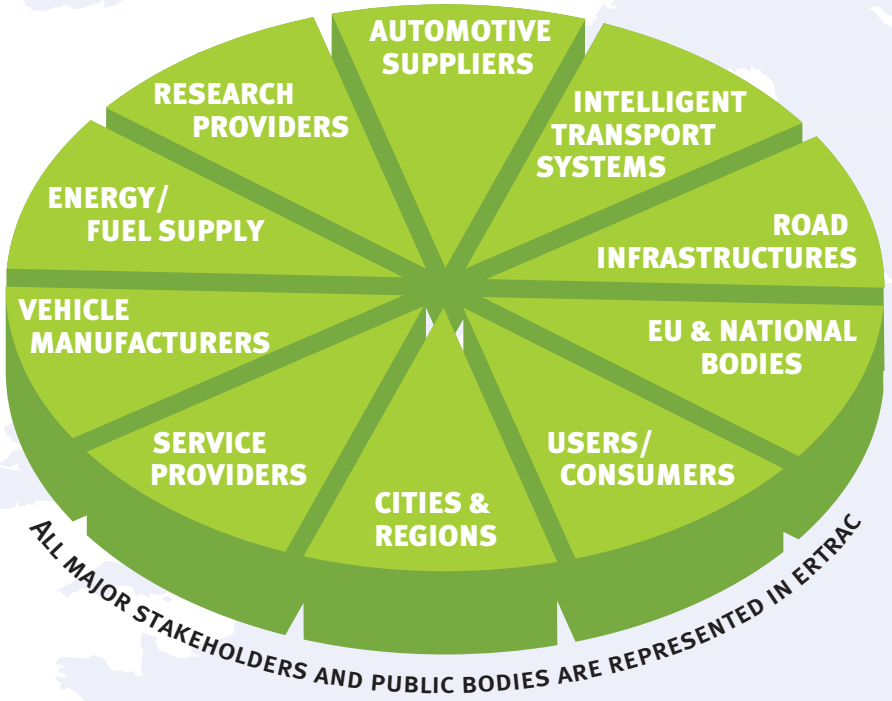
This brochure is the fourth publication of the European Technology Platform ERTRAC following the 'Vision 2020 and Challenges' (June 2004), the 'Strategic Research Agenda' (October 2004) and the 'ERTRAC Research Framework' (April 2006).
This document structures the future research themes according to the priority challenges of the European road transport system and their research needs: Urban mobility, road transport safety, long distance freight transport, as well as the issues of energy, resources and climate change. The research required to meet these challenges were identified by ERTRAC members and other experts and are each summarised in two to three pages.

A systems approach to transport has been promoted by ERTRAC during the past five years. Only a clear structured and balanced consideration of all the areas of road transport, and how Research and Technological Development (RTD) in these areas can advance urban mobility, road transport safety, freight transport, the reduction of Green House Gases and other emissions, and a sustainable use of resources, will lead to significant improvements. Both technical and behavioural sciences are key to finding solutions and to make the right decisions for our society. ERTRAC, as a multi-stakeholder Technology Platform on European road transport, provides road maps for cross-cutting research themes to serve as guidelines for the development of RTD and as a primary reference in the planning of future national and European programmes for research and technological development and for individual research planning.

The European Technology Platform ERTRAC will continue supporting Europe on its path towards a greener, smarter and safer road transport system. If you would like to be informed about ongoing and future ERTRAC activities, visit the ERTRAC website, www.ertrac.org. Your reflections and contributions are welcome anytime.

1.INTRODUCTION

Launched in 2002, the European Road Transport Research Advisory Council (ERTRAC) brought together high-level representatives of all the major European road transport stakeholders for the first time. ERTRAC members represent consumers, vehicle manufacturers, component suppliers, road infrastructure operators and developers, service providers, energy suppliers, research organisations, cities and regions as well as public authorities at both European and national levels. The aim of the ERTRAC initiative has been to develop a common vision, to identify research priorities and to establish a Strategic Research Agenda for the next decades, and to stimulate its implementation. This is the first time that such a holistic view of the road transport research needs had been developed with such active multi sector cooperation.



The first edition of ERTRAC's Research Framework was published in April 2006. It further developed the themes from ERTRAC's 'Vision 2020 and challenges' and the 'Strategic Research Agenda', both published in 2004 (see www.ertrac.org/publications.htm). ERTRAC documents have been developed through a series of intensive workshops and reviews, involving more than a hundred experts from all the above sectors.

This brochure is the first update of the Research Framework and highlights the strategic research priorities derived from the major challenges, which European road transport has to face:

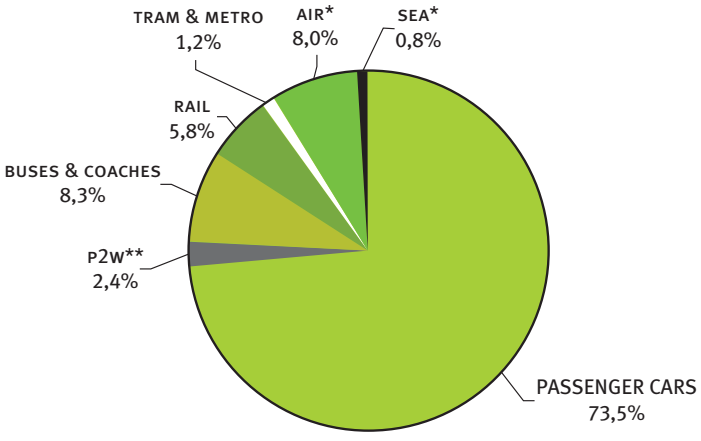
- Urban Mobility
- Energy, Resources and Climate Change
- Long Distance Freight Transport
- Road Transport Safety

ERTRAC's Research Framework reflects the fundamental importance of the road transport sector. Indeed, it is difficult to overstate the key role played by road transport in European society. This sector employs more than 9% of the entire EU workforce, generating a turnover that amounts to 20% of the Union's GDP. Road transport supplies the majority of mobility services demanded by Europe's citizens and businesses. It is responsible for over 75% of inland freight transport and, as such, plays a crucial role in all European industrial and commercial activities.

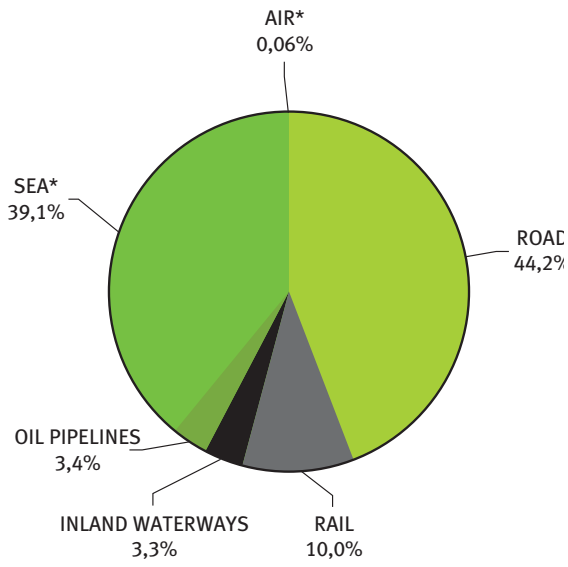
Services provided by road transport are not without a price. Despite significant improvements over many years, the number of fatalities due to road accidents remains unacceptably high. Air quality and noise continue to affect a substantial number of people, and energy consumption in the sector contributes heavily to global greenhouse gas emissions and increases Europe's reliance on external fuel sources. All of these challenges must be addressed at a time when the road sector is facing tough global competition. The Research Framework confronts these and other challenges head-on. For ERTRAC, practical solutions will come through joint, coherent and comprehensive action.

The high level of research investment reflects the central role played by the road sector in Europe. Moreover, road research has a real influence on the overall European research environment. R&D in the sector represents an enormous 30% of overall EU industrial R&D. Not only is the sector one of the most important active players in European research, but it also presents a unique opportunity to forge public-private partnerships. Working closely with the European Commission, the European Technology Platform ERTRAC has sought to foster this kind of co-operative realignment under its Research Framework.

Passenger transport
(passenger-kilometres),2004



Freight transport
(tonne-kilometres),2005



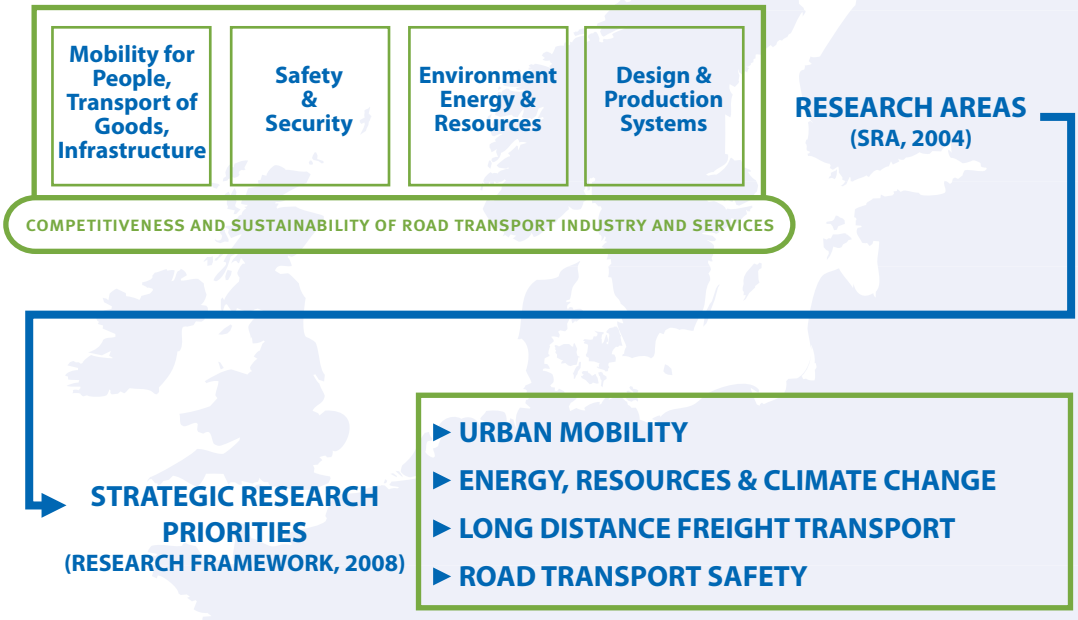
Source: DG Energy and Transport

* Air and sea: data only include intra-EU traffic and are estimates made by the Commission based on airport-to-airport data collected under Regulation (EC) 437/2003 and on port-to-port data collected under Council Directive 95/64/EC.
** 'P2W': Powered two-wheelers

2.THERESEARCHPROGRAMME

The Strategic Research Agenda and the first edition of the Research Framework was focused on four pillars of 'Mobility, transport and infrastructure', 'Safety and security', 'Energy, environment and resources', and 'Design and production systems'.

In view of the significant overlaps and synergies between research issues in the pillars, a new structure to identify research needs was adopted and is presented in this document. This is based on the four strategic research priorities as shown in the diagram below. Significant research issues were thematically grouped and are shown later in the text in the form of fishbone diagrams. In addition the strategic research priorities include the guiding measures needed and research in social and economic topics related to future road transport.



The Research Programme aims to respond to the increasing demand from European citizens for individual mobility, to the evolving needs of society as a whole for road transport, and to the long-standing and fundamental management requirements of one of Europe's greatest assets – its road transport network.

The ERTRAC opportunity

The European road transport industry spends over 30 billion on R&D every year. In addition, much of RTD is financed by the EC, national and regional funds. A better alignment of European and national as well as private and public research activities would provide major benefits in terms of economic efficiency, quality of results and reduced time to application of innovation.

It is ERTRAC's mission to explore those opportunities and make specific recommendations for implementation. ERTRAC's inclusion of all major road transport actors makes it unique and allows a truly holistic and integrated view of road transport issues.

The ERTRAC approach is key to addressing Europe's road transport challenges successfully and effectively, both today and tomorrow. ERTRAC's aspirations include:

- **Defining priorities agreed by all stakeholders**
- **Aligning European and national research agendas and programmes**
- **Monitoring progress and adjusting research road maps accordingly**
- **Providing a platform for ongoing research alignment and co-operation**
- **Making specific recommendations for large cross-stakeholder research**
- **Identifying needs for international and global co-operation**

2.1 Strategic research priorities for road transport

Keeping European people and goods moving has required substantial research and investment over the previous decades and this has resulted in significant improvements in the road transport system. However, major technological challenges still lie ahead in order to ensure that society's expectations continue to be realised for a greener, safer, and smarter European Road Transport System. For this reason, ERTRAC's Strategic Research Priorities have been aligned around four major challenges:

- **Urban Mobility**
- **Energy, Resources, and Climate Change**
- **Long Distance Freight Transport**
- **Road Transport Safety**

Each of these priority areas will be described in more detail in later sections. Although the technological needs in these areas is emphasised, these sections also include comments on guiding measures, social and economic issues, and research tools that will be needed in order to facilitate the development and application of new technology to meet the future challenges of European road transport.

Urban Mobility: achieve sustainable mobility for passengers and freight in the urban environment.

This research priority focuses on the movement of people and the delivery of goods in the urban environment. The aim of this priority is to provide people with high-quality public transport that they will want to use and traffic that is free flowing in the urban setting. Research in this area brings together all of the complexities associated with the urban environment to ensure that an intelligent and efficient road transport network will be a vibrant part of our future. A priority on urban mobility will also help to stimulate less-polluting and cross-modal forms of transport that are creatively linked by effective mobility management schemes. The integration of public and private transport systems will also need particular focus in order to obtain a sustainable intra-modal balance.

At the same time, research on urban goods distribution will be needed to reduce the impact of freight movements on urban residents while maintaining, or increasing, overall efficiency. Research in this area will consider the relationships of freight delivery with extra-urban road transport and other modes including links with personal and public transport. New concepts for urban-friendly freight distribution vehicles, loading/unloading systems, and associated infrastructure will create innovative concepts for reducing noise and pollution.

Energy, Resources, and Climate Change: provide environmentally friendly road transport systems and a secure, renewable energy supply.

This research priority focuses on technologies that will lead to a cleaner, quieter, and more energy efficient road transport system. The future system will be expected to have a minimum impact on communities and natural habitats and be adaptable to the specific needs of different market environments. Of course, the energy supply must increasingly benefit from secure, renewable sources in order to achieve lasting benefits to climate change through sustainable Greenhouse Gas reductions.

Improving our road transport system must be done while simultaneously preserving limited energy resources and the environment. These sometimes conflicting needs can only be addressed through a systematic approach that considers the overall priorities for road transport along with available vehicle, fuel, and road infrastructure technologies, then quantifies the benefits and costs of different options in a consistent and objective manner. Fortunately, analytical tools and models are already well established in the European planning process. But, to be effective in guiding future activities, these approaches need to be continuously updated and adapted as needs and knowledge evolve.

In the long run, however, advances in light-duty and heavy-duty vehicle technology will underpin objectives in energy, resources, and climate change. Vehicles powered by advanced internal combustion engines will continue to be the propulsion backbone for some time, as increasingly sophisticated drivetrains and fuels are developed. To realise the potential for lower emissions and increased energy efficiency, a systematic approach is needed for research covering these new advanced combustion processes with integrated after-treatment and transmission systems, together with optimum fuel formulations (including synthetic and bio-components).

The overall research challenge is to deliver low emissions while also meeting individual and societal demands for mobility, vehicle performance, reductions in greenhouse gas (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.

- Improvements in vehicle efficiency can deliver as much as a 40% reduction in CO_2 emissions for passenger cars and 10% for heavy duty vehicles (compared to a 2001 baseline) for the new vehicle fleet in 2020.
- Good vehicle maintenance and driving for fuel efficiency will reduce fuel consumption and CO_2 emissions by at least 10% for cars and 5% for heavy duty vehicles.
- Improvements to the road transport infrastructure, best use of transport modes, information technology systems will contribute to further reductions in fuel consumption by 10-20%.
- Further reductions of carbon emissions associated with fuel production will be achieved.
- On the long term, 2020 and beyond, fuel cell vehicles and low carbon / hydrogen fuels will begin contributing to carbon reduction.

Long Distance Freight Transport: decrease the environmental impact of long distance freight transport.

This research priority recognises that Long Distance Freight Transport is increasingly responsible for the majority of Europe's goods movements. Since goods movement is closely related to economic growth and competitiveness, a rational and specific focus on this area is vital. Increasing freight transport has the potential to increase traffic congestion on major highways and the deterioration of road infrastructure while improving road safety to non-freight traffic. Noise and exhaust pollution must also be controlled as well as road fuel demand associated with freight transport. For all of these reasons, it is vital that Long Distance Freight Transport is locally and regionally optimised in order to improve overall efficiency and effectiveness, and reduce the impact on communities and their environments.

The transport of goods across Europe will be made more efficient with a better understanding of distribution practices. With appropriate infrastructure, new concepts such as road-trains could dramatically increase the efficiency of individual vehicles for long-distance journeys. Infrastructure dedicated to freight transport could allow roads, bridges, and tunnels to be optimised for particular types of vehicles reducing infrastructure maintenance and environmental impact.

Road Transport Safety: reduce road transport injuries, fatalities, and accidents.

This research priority focuses on how better integration of research and development concepts can improve safety in the road transport sector. The European Commission's Road Safety Action Plan and the eSafety Programme have set a target for reducing road accident fatalities by 50% in 2010 (compared to a 2001 baseline). In order to reach this objective and continuously reduce future fatalities, this research priority proposes an integrated R&D approach covering accidentology, preventive and protective safety, co-operative systems, and emergency management. Human factors studies and network infrastructure improvements will also be needed to achieve these safety objectives.

Such an approach will extend the focus of road transport safety beyond the vehicle itself to include the way in which the driver perceives information on the road/traffic and responds to this information. The aim of the research should be the improvement of this process, through new technologies to help the driver in controlling the vehicle and to facilitate the adoption of 'safe' decisions, thanks a better driver perception and awareness of the risks involved. The final objective is to convince the driver to always adopt a safe behaviour that allows him/her to control all situations without or with minimal accident risks.

Having briefly described the four Research Priorities, it is important to put them in the proper context of the social, political, and business environment that will be needed to ensure continued progress in addressing these challenges.

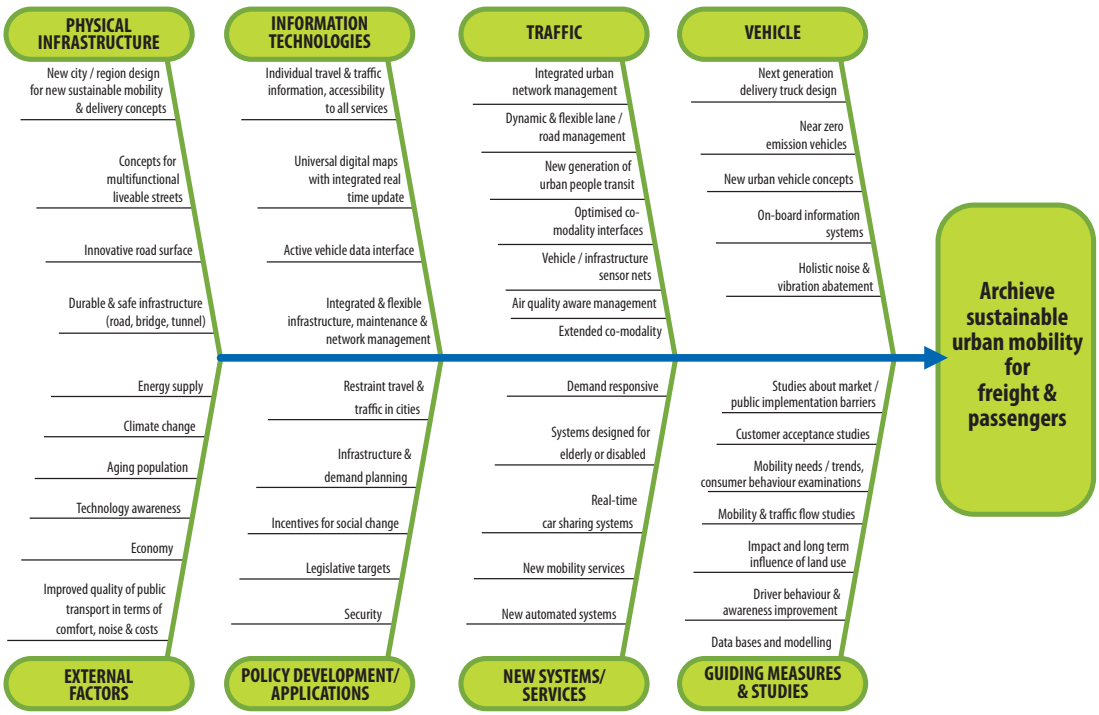
Technological Advances are Only Part of the Solution

History has shown that new technological advances have a much higher probability of achieving their full potential when they are developed and implemented within a receptive marketplace. For this reason, the Strategic Research Priorities described in this document must be underpinned by enabling studies in behavioural changes, social and economic trends, and tools and modelling.

Society's reliance on road transport system has the potential to negate continuing improvements in transport efficiency. For this reason, social trends and measures that reduce growth in demand for personal mobility and transport of goods while maintaining economic and social well-being will have a positive impact on both emissions and energy consumption. Vehicle and road technologies can contribute to fuel-efficient driving patterns, but driver behaviour is also an important contributor.

Finally, appropriate data and research tools are needed to drive this understanding and innovation. Models of human interactions and user acceptance to different mobility modes must be defined. And, common methodologies for routinely collecting and interpreting mobility information will be needed that span European and international boundaries.

▶ 2.1.1 Urban Mobility



Individuals will make urban transport decisions which they believe best suit them, whether this is for personal travel, or as company decisions for the movement of people and goods. The decisions will be based on a complex balance of factors such as cost, convenience, journey time, reliability, safety/security and comfort.

To achieve sustainable urban mobility, transport systems and services must be provided which encourage and enable individuals to make appropriate travel and transport decisions to suit their personal circumstances and societal needs. The activities which are defined in the diagram above identify specific areas of broader research which need to be addressed to develop the systems and services themselves, as well as to understand behavioural responses and the ways in which they may be accepted by, and influence, transport behaviour in both the short and long term. The key threads which run through the research are the provision of timely, accurate and relevant information to people before and during travel, so as to make the best use of available infrastructure through the use of technology. This includes new vehicle technologies and their integration with infrastructure. This provision will be in the context of local policy objectives which may relate to the environment, congestion, safety, economy and society. A base of knowledge of current and forecast network conditions is needed and new detection/monitoring systems and studies will enable improved decision making at all levels to be more effective.

Land-use patterns and travel needs have implications for the amount of **physical infrastructure** required and how such infrastructure should be allocated to different user groups including considerations of concepts of multi functional liveable streets. Research is needed into better understanding the many links between land use and transport, particularly how new sustainable mobility and delivery concepts may be integrated. Urban road infrastructure must be safe, environmentally acceptable, and consistently available for use.

Research into **information technologies** is needed to be able to provide travellers with up-to-date information relating to the road network, public transport, and walking. Many companies are producing products in this area and key research will provide the consistency of data bases and interfaces necessary to make maximum use of the technological opportunities.

New integrated urban **traffic** management systems will be able to be developed on new information streams such as may come from greater knowledge of origin/destination patterns, and sensor nets. These may involve dynamic and flexible lane/road management and vehicle/infrastructure technologies. The on-line management and prioritisation of availability of road space may be focused to support policy objectives such as a new generation of urban people transit and air quality/carbon management. Research into the provision and management of effective interchanges between services is important to support seamless sustainable journeys and goods movements and promote multimodal travel decisions.

Research into new concepts for **vehicle** design and operations will result in low or zero carbon vehicles appropriate for short range urban use and with new approaches to vehicle ownership and use. Holistic approaches to vehicle design for noise and vibration abatement and coordination with infrastructure will address local environmental issues. The substantial growth in urban deliveries, resulting largely from increased internet purchasing, will require new delivery vehicle designs and concepts. On-board systems will encourage safer and more environmentally sustainable behaviour.

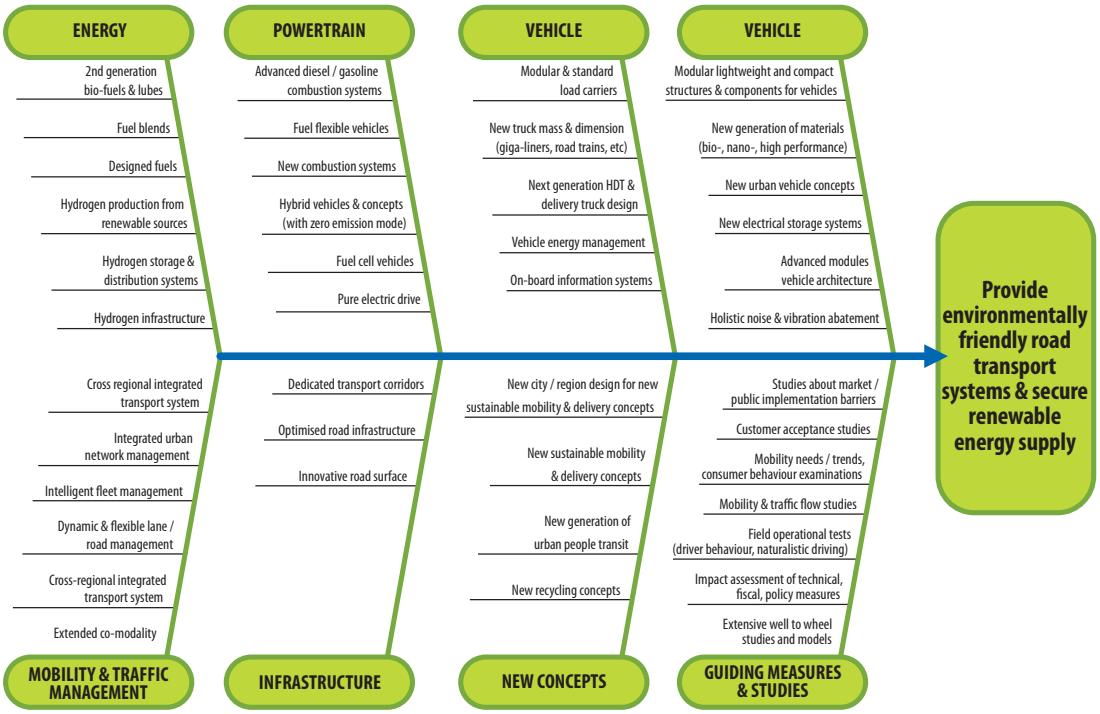
New systems and services will need to satisfy urban mobility needs. These will include demand responsive services to fill the gaps between cars and conventional public transport and integrate with them in an urban context. Some services may involve fully automated vehicles at various levels of segregation in the urban network. Further research into the role and potential of a variety of real time car sharing systems is needed as part of a range of new mobility services targeted at the wider diversity of user needs.

Systems and services based on new technologies will not only influence **policy**, but will also enable policy applications to be refined and new urban policies to be developed. Research will need to be targeted at the development of evidence to specifically inform and influence policy in a range of areas including balancing infrastructure and demand, and the development of policies to actively and effectively manage congestion/environment. Understanding how a variety of incentives may be used to influence transport behaviour are key areas of research and relate to market opportunities. Understanding better legislation/decision processes and security issues are important.

The future is likely to be a time of substantial change and a range of **guiding measures and studies** are needed to understand such changes before and as they take place, and to determine the influences which may lead to a more sustainable future. Research will include studies to understand market factors and changes in behaviour at all stages of travel decision making. Monitoring land use changes and their impacts will be particularly important aspects of new data base and modelling systems.

The demand for transport must be sent in the context of a wide range of **external factors**. Effects of changes in the availability and cost of energy, levels of economic activity, aging and migration population issues, and evolving levels of awareness and evolving attitudes to global warming and technology will all need to be better understood in an urban transport context. Most particularly, changes in the non road-based modes of rail and metro systems need to be both understood and integrated into common policy and applications.

▶ 2.1.2 Energy, Resources and Climate Change



The improving of mobility has to be in line with preserving energy resources using the benefits of energy- and material circles and without degrading the environment. This task can only be effectively addressed through a systematic approach, considering all available fuel and vehicle technologies, priorities for transport planning and road infrastructure technologies, and after fully and accurately quantifying the costs and benefits of all options. 'Energy, Resources and Climate Change' is divided into the following priority sections:

On the passenger car side, new urban and long distance **vehicle** concepts have to be based on modular, lightweight and compact structures and components with new generation of materials (bio- nano- high performance). For local zero combustion emission, vehicles with new electrical storage systems have to be researched on. Reliable totally accident avoiding systems could offer to reduce weight and costs of total ownership and could preserve energy and resources. The vision is to reduce harmful effects of noise exposure from all sources and to preserve quiet areas in cities and suburban areas. Key topics for research are low-noise roads and infrastructure, the interaction of tyres and road surface, low-noise lightweight vehicle structures and active noise control.

Especially on the heavy duty side the question of designing the next generation of HDT and delivery trucks has to be solved. Included are the new truck mass dimension (giga-liners, road trains etc.), modular and standard load carriers, on board information systems and vehicle energy management.

Road transport-related emissions are not limited to CO_2 and NOx. Particulate matter and vapours are also released directly into the atmosphere. With considerable reductions in emissions having been achieved over recent decades, based largely on powertrain improvements, the balance of emissions from vehicles is gradually shifting to other sources. Research in this area will consider tyre wear, brake wear, and road surface wear. Meanwhile, as emissions from vehicle exhaust decline, an update of evaporative emission factors from vehicles and the fuel-distribution system is now in order. The relative contributions of fuel permeation and breathing losses to evaporative emissions need to be established. Other sources of emissions, such as plastic materials in vehicle interiors, also require close attention.

Research in the area of **powertrains** must target near-zero exhaust emissions of pollutants by 2020, and the advancement of better technologies for a potential overall CO_2 emission reduction will continue to be the primary workhorses in road transportation, as powertrains for passenger cars, and light- and heavy-duty trucks. Before the results of the second generation of bio-fuels will give a stabile base for engine application, fuel flexible vehicles offer a way to use the fuel diversity and its fuel blends in the near future. Once again, realising the potential for lower emissions and increased energy efficiency calls for a systems-based approach, including research covering new advanced combustion processes with dedicated transmission and integrated after-treatment. Optimum fuel formulations could include synthetic and bio-components.

A key factor in the successful development and introduction of new technologies will be the use of new-generation vehicle and powertrain design tools, including multidimensional simulation techniques for detailed component and process design, multidisciplinary simulation and multi-objective optimisation methods. Research on hybrid powertrain should focus on the development of full hybrid vehicles with all-electric drive and near-zero emissions driving modes. This means aiming for the most stringent urban emission targets while still maintaining competitive costs. Research will include hybrid design, energy management, component development, optimisation and integration. As already mentioned the electric storage of energy is one of the key technologies of the future.

Energy from biomass and waste represent the most readily available alternative fuel source in the short- to mid-term. Research should consider the advantages of bio-fuels of the second generation, which can be blended with gasoline and diesel and are compatible with advanced ICEs. Research will also consider the substantial improvements needed in terms of bio-fuels production costs and the efficiency of greenhouse gas reduction and energy savings. Research and development will focus on two emerging technologies in particular: the production of ethanol via enzymatic fermentation, and gasification followed by synthesis, including Fischer-Tropsch products. Bio-fuels of the second generation implement that there is no competition between alimentation and energy for mobility. Designed fuels help to come to very efficient new ICEs with zero impact emission.

Hydrogen represents a great potential energy carrier over the longer term, beyond 2020, but research is urgently needed to develop both highly efficient fuel cell vehicles with acceptable energy balances and ranges and new methods for low-carbon hydrogen production. Achieving this will require a focussed and sustained research effort, as is currently being addressed in detail by the Hydrogen and Fuel Cell Technology Platform.

The roadside environment can form a valuable refuge for flora and fauna, but they can be severely affected by routine or accidental emissions. Road transport corridors can also have an impact on local water and soil quality. Research in this area will address rising concerns about contaminants, human health and ground water quality.

Research will also consider **mobility management and advanced traffic management**. Improved management of the road network, of traffic and of infrastructure operation, can make a significant difference in terms of environmental performance, delivering improvements on many environmental and societal levels. Research in this area will focus on integrated traffic management, better vehicle labelling systems, and the development of systems for energy recovery and network design.

To reduce the adverse effects of road and **infrastructure** design on fuel consumption and air pollution; and improving the sustainability of materials use will also support network operations considered under the topic of mobility management. A significant proportion of fuel consumption is linked to the simple fact that vehicles must drive across a road surface. This is particularly the case for trucks, where 40% of rolling losses while travelling at 85 km/h arise from the tyre/road interface. Priorities for research include tyre/road rolling losses and resource use.

Regarding the growing demand for mobility and the growth in traffic, one has to think about **new concepts** for city and region design, totally new sustainable mobility and delivery concepts and about a new generation of urban people transit.
To help our environment new recycling concepts are urgently necessary.

Applied within the framework of a comprehensive and systematic approach, **guiding measures and studies** will be an important resource to shape research planning and policy decision-making. They will be used to collect information on changing demographics and transport needs and will enable the development of realistic projections for the future. In addition, work is also needed to develop communication tools to aid in the dissemination of study results. Only in this way can such work truly have its intended effect in terms of enhancing policy-making.

Clearly, the projected growth in demand for mobility of people and goods will have a significant impact on the ability to control Europe's vehicle emissions and energy demands. Forecasts for 2020 show a 32% increase in individual demand for travel, and an even bigger predicted 69% growth in the amount of goods transported.

▶ 2.1.3 Long Distance Freight Transport

Road freight transport is responsible for the overwhelming majority of goods movements across Europe. There is a strong link between these movements and Europe's economic prosperity. The transport of goods by road remains, and will remain, a key pillar of the core European Union objectives for the unrestricted flow of goods especially where this involves communities on the margins of Europe. However such movements can also have adverse societal impacts. Improvements in the overall efficiency of the goods transport system (including where appropriate multi-modal journeys) is necessary to both improve Europe's economy and standard of life. In conjunction with improvements to the standard of life. With the growing contribution of road freight movements towards green-house gas emissions and the heavy reliance on imported energy supplies, it is urgent that substantial steps are taken to improve the system. It is vital that innovations are developed that will allow the overall system to be optimised 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

The diagram above represents a comprehensive, yet pragmatic, strategy to develop the tools needed to improve Europe's freight transport systems. The individual elements of the planned research will make a major contribution. The transport of goods across Europe will 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 costs, traffic accidents and environmental impact. Furthermore, the research considers far-reaching concepts such as systems for powering long-distances trucks through alternative, greener sources of power.

In the research activities, new generations of Heavy Duty **Vehicle** (HDV) design will include innovative concepts for future types of trucks and modular goods carriers, for different types of freight, and effective road-rail combinations will be developed. This research will include Intelligent Inter-modal Transport Units (ITU) for modular goods movement on a European level will be developed. To increase the efficiency of goods transport, research will be conducted on addressing the challenges and advantages of new weights and dimensions. Developments and demonstrations will be conducted to into the technical issues concerned with the construction and operation of these longer and heavier road freight vehicles. This will include manoeuvrability of multiple articulated units longer than 25 metres and of platooned convoys. Supporting this, activities will also consider modular, lightweight and compact structures & compounds; truck energy management; advanced diesel combustion systems; fuel flexible trucks and new combustion systems. Further developments in hybrid technologies for trucks will include the feasibilities of multi-powered vehicles based on recent developments in bus technologies will include the use of overhead catenary systems for providing external power on long-distance, environmentally sensitive sections. Fuels cells technologies will be developed for auxiliary power units (APUs). The reduction of air- and ground-borne noise and vibration from heavier vehicles will be brought about through developments in controlling low frequency transmission of tyre/road and engine noise.

The innovative developments in **infrastructure** will include a focus on dynamic and flexible lane/road management for the purposes of heavy vehicle goods transport. This work will include the concepts of dedicated transport corridors that will be designed, maintained and operated from the perspective of green and efficient heavy vehicle. This will include infrastructure technologies appropriate for longer, heavier and platooned vehicle and road-train combinations. Optimisation of these systems with modal interfaces and/or shared infrastructure will be considered. Development of network level systems will support the transit of larger goods vehicles (including those of 60 tonnes or more). This large-scale research will consider the issues of bridges, tunnels, steep gradients and congested or environmentally sensitive areas and provide technologies for increasing the durability and safety of the network and its components. Real-time and seasonal effects will be examined to maximise the effectiveness of the system in all weather conditions. New tools and models for the efficient asset management of both overall network and individual sections will be developed to improve the overall life cycle costs. Appropriate road classifications for the efficient operation of modular vehicles and road-train combinations will be developed through coordinated activities with national and international programmes. Innovative road surfaces will be developed with a focus on reducing the energy losses of heavy vehicles, reducing noise and reducing road maintenance. Communications between vehicles and infrastructure will be developed with improved vehicle/infrastructure sensor nets. Finally in a more far-reaching activity, new forms of city/region design for sustainable delivery concepts will assist land-use planners, policy makers and industry to develop the integrated landscape of the future.

The research strategy of long-distance road freight transport also recognises the importance of Modal Interfaces. The transport operations of the future will benefit from advanced intelligent fleet management interfacing effectively with a cross-regional integrated transport system. The technical and systems developments will not only consider transport activities but also provide integrated solutions for commercial/industrial logistics including optimised co-modality interfaces with the hubs and nodes of the system. Transfers with transport hubs will benefit from improved modular & standard load carriers.

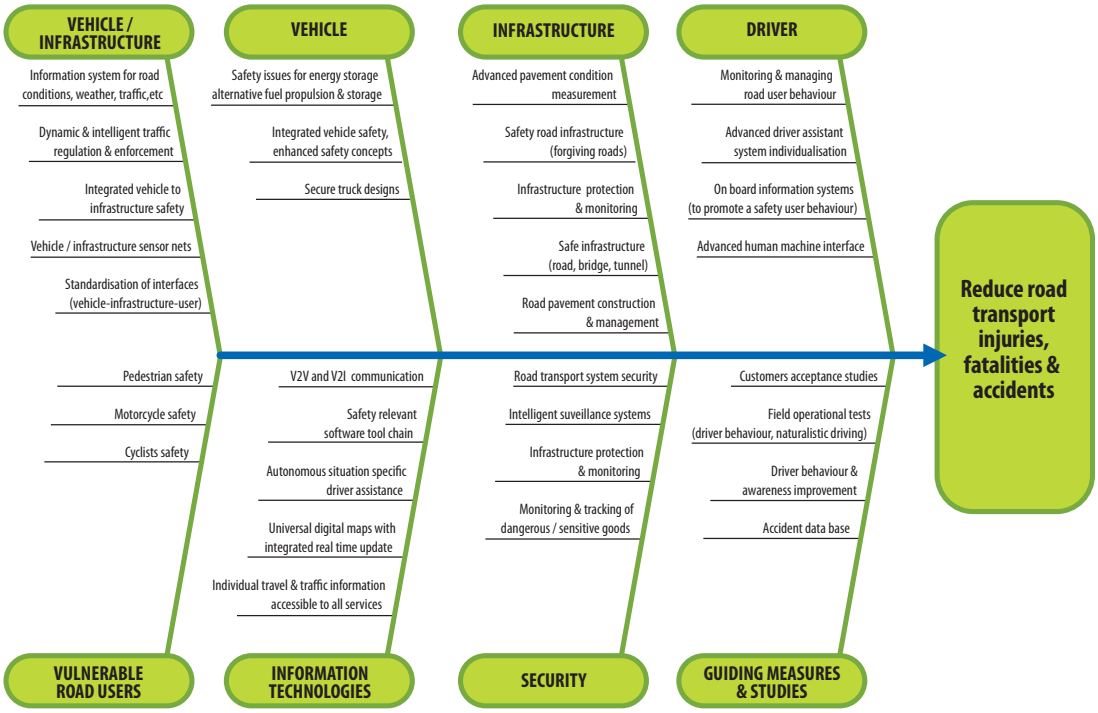
Improvements in the **safety** performance of long-distance freight transport will consider the vehicle, infrastructure, driver and the linking systems. One aspect of this will be improved information system for road conditions, weather, traffic; etc that are focused on the particular needs of long-distance haulage operations. Safer road infrastructure will include new technologies within and alongside the road. Activities will include safety fences especially for potential hazard points such as on bridges where containment of large vehicles will be assured. To ensure safety on a daily basis, advanced pavement condition measurement systems will be developed. Maintaining the correct use of trucks will be assured through the development of dynamic and intelligent traffic regulation and enforcement which ensures that large vehicles follow appropriate routes and operate appropriately. Advanced driver assistance systems will further support road transport professionals in ensuring safe and efficient operations.

Ensuring the **security** of the driver and goods is a priority. Research developments will improve the security of track design to prevent intrusion and theft. Such systems will also consider the links with systems in parking areas and other higher risk environments. The research will consider intelligent surveillance systems for the security of both vehicles, drivers and infrastructure, In the later case, special consideration will be devoted to reducing and mitigating the impacts of terrorist, criminal and other malicious activities (including cyber-crime). This will consider new designs for the physical and electronic infrastructure and their efficient and secure integration., Development of monitoring and tracking technologies will be carried out in order to establish a secure, seamless information chain for the transport of hazardous goods. This will integrate the special features of the hazardous load, for example toxicity to aquatic life, with relevant routing information on vulnerable situations such as the location of rivers.

Improved **information technology** systems will include the development of universal digital maps for navigation and positioning with integrated real-time updating and active vehicle data interfaces and vehicle-to-infrastructure communication. At the network level, integrated and flexible maintenance and network management systems will support the effective management of the infrastructure and traffic as a complete system to ensure maximum infrastructure capacity usage and life-time utilisation.

The overall effectiveness of the research developments will be supported and guided by relevant **guiding measures and studies**. These studies will consider the barriers to market and policy implementation including the important issues of public acceptance of identified solutions. These studies will also consider how any public reluctance can be better informed by appropriate demonstration and other awareness activities. The important considerations of safety for long-distance freight transport will be monitored through appropriate database tools and systems. The overall assessment of the European road freight transport current and future performance will be considered through studies into traffic flow, the impact assessments of technical, fiscal and policy measures including consideration of the effects of demand suppression, modal-shift and the influence of road pricing. Robust indicators on freight transport efficiency, journey time reliability, and network efficiency will be developed through coordinated activities.

▶ 2.1.4 Road Transport Safety



Road safety is a high priority for European Research, since road accident cost is orders of magnitude higher compared with other types of transportation. Vehicle technologies have been improved in these last years but is clear that only through an integrated approach, that involve all interested stakeholders, significant results will be achieved. This approach should not only involve vehicle manufacturers, road operators and infrastructures but also promote solutions and policies to increase driver awareness and improve his/her safe behaviour through complete information about vehicle surroundings; this will allow him/her to take the preventive actions needed to avoid accidents.

Driver

The **driver** factor is clearly the first cause of accidents. While general efforts have to be devoted towards the promotion of a safer driver behaviour, research has to develop solutions to help or convince driver to adopt this behaviour.

▶ On board information systems (to promote a safe driver behaviour)

Investigations of human behavioural adaptations to the introduction of new autonomous/supervised/co-operative driver assistance systems should be conducted, with the aim to improve user acceptability and adoption of **safe behaviours**.

▸ Driver Monitoring

On board recognition of driver's inability, drowsiness, distraction, fatigue, drugs and alcohol abuse, through direct measurement and/or real time driver behaviour analysis, may enable recovering strategies to control vehicle dynamics, limit speed and make emergency stop manoeuvres. Research should evaluate and assess potential of low cost technologies **to achieve an effective level of driver's activity monitoring** and algorithms and strategies of intervention on vehicle dynamics.

▸ Advanced Human Machine Interface

Research on HMI integration should include an investigation of how different applications (including nomadic devices, remote services, driving information & warnings and co-operative systems in general) could **share a common in-vehicle HMI in a safe, efficient, and standardised way.**

▸ Monitoring & managing road user

All road users, including vulnerable ones, have to cooperate. New solutions to monitor the **behaviour of all road users,** in particular areas of high danger (intersections, school, etc.) should be developed.

Vehicle

▸ Sensors/Actuators

Further research should be aimed at decreasing the cost and increasing the reliability and redundancy of sensor and recognition technology. Sensor monitoring includes vehicle safety critical components and critical external situations (environmental, obstacles, etc). An open, scalable safety critical electronic architecture is also a high priority.

▸ Advanced driver assistant system individualisation

The acceptability of driver assistance systems requires that the system behaves as user expects, to avoid driver refusal and then the need of enforcement like in safety belts adoption. Research should find solutions where the **assistance systems 'learn' the best way to assist any single, specific, driver** and then to adapt the parameters to him/her automatically.

▸ Integrated vehicle safety, enhanced safety concepts

Based on current on-going research a new concept of integrated vehicle safety should be developed, where the in-vehicle systems have **more 'authority' on the vehicle control,** and then they could intervene more actively in (potentially) dangerous situations.

▸ Safety relevant software tool chain

Research should investigate the development of software tools **to guarantee safety critical functions robustness** against software programming errors.

▸ Autonomous situation specific driver assistance

There are specific situations, for example low speed manoeuvres or highway stop and go, where it could be considered to have a full autonomous driving of the vehicle, since the driver has always the time to perceive a danger or a warning alarm and to intervene when the autonomous system fails or is not able to establish the right action to perform. Autonomous manoeuvres allow improving safety while reducing fuel consumption and driver stress.

Infrastructure

Road infrastructure will play an important role in improving the safety, increasing the information available for the road users, adopting a safe behaviour and protecting the 'non equipped users', mainly vulnerable ones.

Research has to focus these points:

- develop a complete **information systems for road condition, weather, traffic, work in progress, accidents, etc.,** together with the communication technology to send the information to vehicles;
- sensors and solutions for **advanced pavement condition** monitoring;
- development of a general concept of a passive and active **safe road infrastructure** (forgiving road), allowing a certain level of error to road users;
- definition of a common methodology and criteria to evaluate road safety and then avoid, reduce or, at least, signal the dangerous black spots;
- develop cooperative solutions to protect vulnerable, not equipped, users.

In a longer term research has to be dedicated to integrate all previous and following aspects to develop a dynamic and intelligent traffic regulation (and enforcement).

► Integration and Cooperation

The main benefits are possible when all different actors, driver-vehicle-infrastructure, cooperate to reach the maximum level of safety. This requires an exchange of information between these actors, between vehicles and with the infrastructure.

The first priority is then the development of a safe communication network among vehicles and with the infrastructure **(V2V & V2I communications).** Based on this network a new concept of **integrated vehicle-infrastructure safety** could be developed.

► Impact assessment

Understand the benefits (and maybe the negative effects) of all the future advanced safety improvement solutions is of utmost importance to allow the planning of incentives, like insurance cost reductions or public contributions. Research activities have to focus on Field Operational Tests (FOTs), where a large fleet of vehicles will be equipped and used (in normal traffic condition or in specific test tracks) to understand the effects of a solution in term of accident risk reduction.

Security

Intelligent surveillance of road infrastructure

The 'public' characteristics of road network and public transport allow the use of this public infrastructure also for criminal actions. In particular this factor reduces the level of utilisation of the public transport network.

Secure truck

With the increase of transportation between Europe and East countries security problems will be more important in the next years. Research should be focus in finding solutions that detect the criminal act, in real time and without the contribution of the driver, avoid the relative consequences by stopping the vehicle and allows an intervention before the freight will be transhipped on another vehicle.

Infrastructure protection and monitoring

Some infrastructures, like tunnels and bridges, are very sensitive for the overall transport and could be objectives of terrorist acts. Monitoring of these infrastructures with military forces is very expensive, and cannot be extended to all points. Research should be devoted to the development of technologies and solution that allow an inexpensive monitoring of this large structure, with minimal human intervention.

Monitoring & tracking of dangerous/sensitive goods

The transportation of dangerous goods has to be monitored and controlled to avoid any wanted or unwanted accidents. Research should focus on achieving very high level of driving safety, minimising the risks along the route and monitoring the vehicle and freights. The level of security, since this type of vehicle could be used for acts of terror, has to be well above what we have just for normal freight.

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